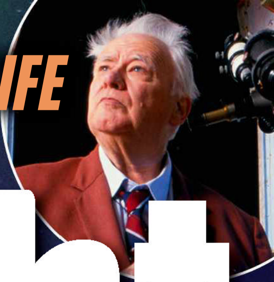
BBC

PATRICK MOORE AT 100: CELEBRATING HIS LIFE



#214 MARCH 2023

# Sky at Night

THE UK'S BEST-SELLING ASTRONOMY MAGAZINE

## INVESTIGATING THE AURORA

What drives the Northern Lights and why now is the best time to see them

**PLANETARY PAIRINGS**
Observing details for all of March's best conjunctions

GET TO KNOW VENUS THE EVENING STAR

HOW IS THE UNIVERSE SO BIG? FIND OUT INSIDE!

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# Welcome

## Discover the workings of the endlessly intriguing aurorae

The Northern Lights have lit up our skies already this year, with bright displays visible in Scotland, northern England and, during one particularly energetic display, as far south as Norfolk. But why do we see more aurora activity in the winter and spring months? On **page 28**, scientist Maria-Theresia Walach reveals all, explaining why displays are often most energetic in March (spoiler alert: it's not just because the nights are longer!) and how these enchanting light shows are the spectacular sign of our planet's connection with its star 150 million kilometres away.

Also in this issue, we mark what would have been Sir Patrick Moore's 100th birthday. On **page 60,** we look at what made him Britain's best-loved amateur astronomer, while on **page 18** Chris Lintott shares personal memories of working with him on *The Sky at Night*. Then on **page 66**, join Steve Richards for a tour of 10 of the best objects to observe this month from Patrick's own Caldwell Catalogue.

Venus will be an unmistakeable twilight fixture in the west and climbing higher in the sky throughout March. It's a great time to view this mysterious planet in more detail, and the BAA's Venus section director, Paul Abel, is at hand on **page 35** with expert advice on how to do it. If you're unable to get to a telescope, fear not: Venus takes part in several lovely close approaches with other planets which are visible to the naked eye. You'll find all the details in the Sky Guide, starting on **page 43**.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 23 March.

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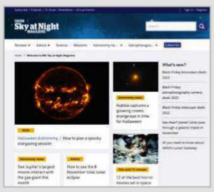
## Sky at Night – lots of ways to enjoy the night sky...

### Television

Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18



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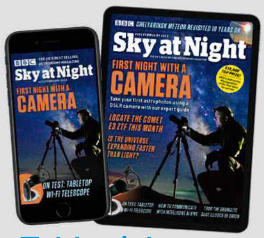

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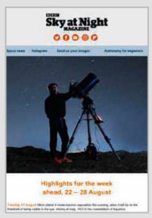

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The best targets to observe each week, delivered to your inbox. Visit **bit.ly/skynewsletter**

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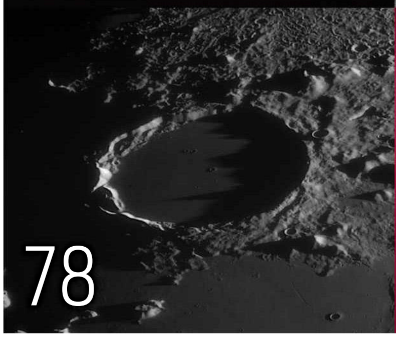
C = on the cover

# New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**





## This month's contributors

### Maria-Theresia Walach

**Ionosphere scientist**

"The aurorae allow us to see the interaction between what's in space and Earth's atmosphere, and interrogate the physics that drives this incredible phenomenon." **Discover the science of the aurorae, page 28**

### Steve Richards

**Expert astronomer**

"Patrick Moore's 100th birthday is a great excuse to explore his own deep-sky catalogue and observe some wonderful celestial objects." **Join our tour of 10 Caldwell Catalogue targets on view this month, page 66**

### Melissa Brobby

**Science community**

"It was fascinating to learn from Dr Gramellini about how neutrinos could hold the key to understanding our Universe." **Turn to page 98 to find out how these tiny particles could solve the riddle of antimatter**

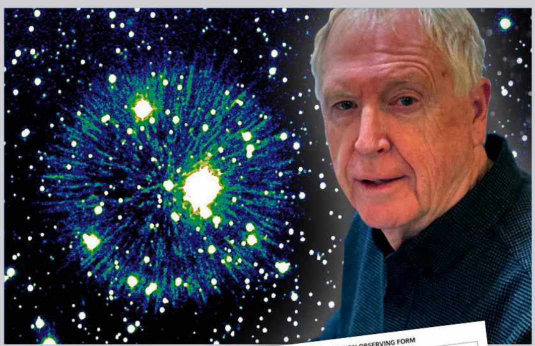
# Extra content ONLINE

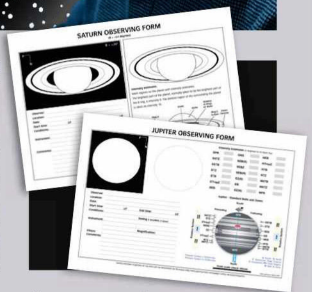
Visit **www.skyatnightmagazine.com/bonus-content/UTDXPBX** to access this month's selection of exclusive Bonus Content

## MARCH HIGHLIGHTS

### Interview: When white dwarfs collide

Astronomer Robert Fesen reveals how he observed an 850-year-old stellar collision, and looks at its implications.





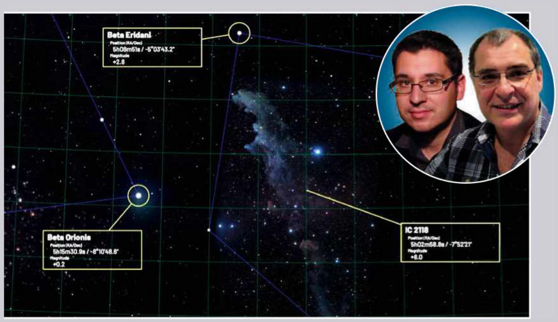

### View our online astrophoto gallery

See this month's selection of photos captured by *Sky at Night Magazine* readers and humanity's most powerful telescopes.

### Access extra observing materials

Download and print out forms to sketch and record your planetary observations throughout the year ahead.

### The Virtual Planetarium




Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

EYE ON THE SKY

# LAGOON SHOW

A star cluster embedded in a nebula makes for a smoky spectacle

**HUBBLE SPACE TELESCOPE, 12 DECEMBER 2022**

NGC 6530 is an open cluster within the Lagoon Nebula, rendered by Hubble's keen gaze and distinctive colour palette into a billowing mass of layered clouds pierced by the white-hot pinpricks of stars. A lot of what you can see is ionised hydrogen, laced with dust, and the nebula as a whole is known for forming this into new stars.

There are several thousand stars in the cluster, though only six are bright enough to see with binoculars from Earth. You'll find it around 4,350 lightyears away in the constellation of Sagittarius, where it stretches across 14 lightyears. Hubble was looking for proplyds, ionised planetary discs surrounding young stars that are commonly found in the Orion Nebula, but are rare elsewhere. To do this, it used its Advanced Camera for Surveys and Wide Field and Planetary Camera 2 to gather near-infrared light from the nebula, resulting in this image.

ESA/HUBBLE & NASA, O. DE MARCO; ACKNOWLEDGEMENT: M.H. ÖZSARAÇ

MORE **ONLINE**
Explore a gallery of these and more stunning space images

## △ Dark materials

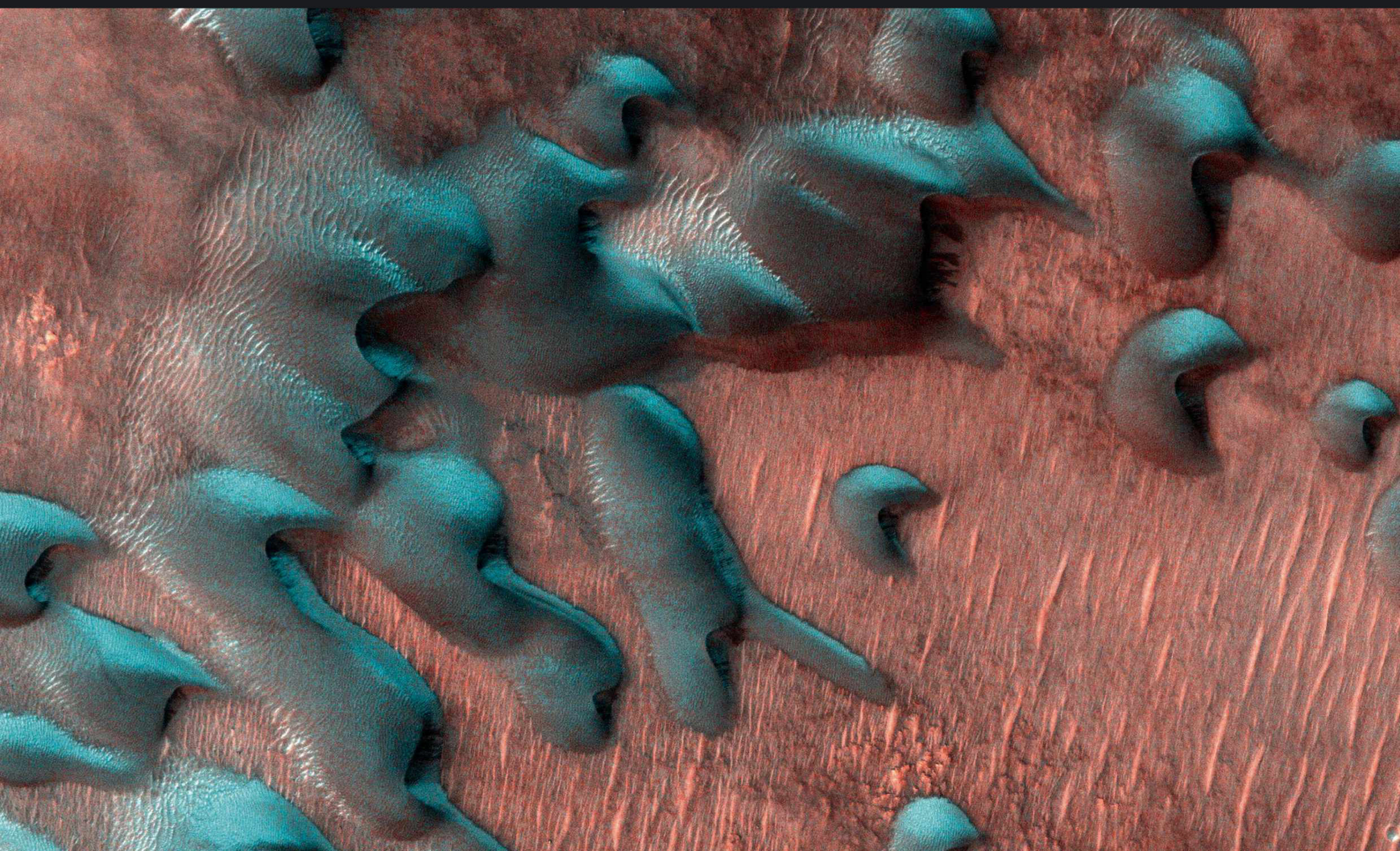
**JAMES WEBB SPACE TELESCOPE, 23 JANUARY 2023**

Lit by the glow of the protostar hidden at the upper left, the dark molecular cloud known as Chamaeleon I, 630 lightyears away, attracted the attention of JWST's Near-InfraRed Camera due to the presence of ices in its chilly folds. As well as simple ices like water, these frozen molecules included ammonia, methanol and methane – the chilly ingredients for what may one day, once heated up, form young planets and stars.

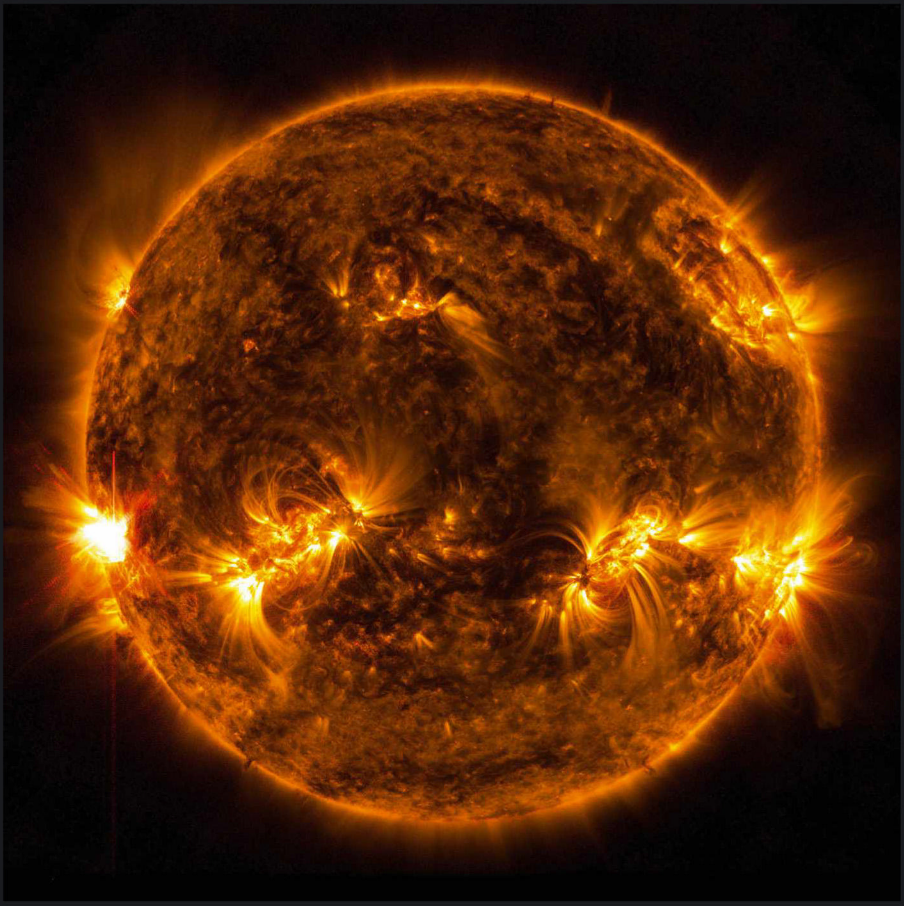
## ▽ A snow day on Mars

**MARS RECONNAISSANCE ORBITER, 22 DECEMBER 2022**

This is Mars in winter, as seen from orbit with an ultra-high-resolution camera. These snowy sand dunes are topped with a mix of dry and water ice, but it's the frozen carbon dioxide that's most likely to linger, as water ice turns to vapour in the thin Martian atmosphere. And as carbon dioxide forms four bonds when it makes crystals instead of six like water, the dry snowflakes on Mars are cube-shaped, instead of the six-sided ones we're used to on Earth.



NASA/ESA/CSA AND M. ZAMANI (ESA/WEBB)/SCIENCE: F. SUN (STEWARD OBSERVATORY)/Z. SMITH (OPEN UNIVERSITY)/AND THE ICE AGE ERS TEAM, NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA, KPNO/NOIRLAB/NSF/AURA/P. MASSEY/IMAGE PROCESSING: T.A. RECTOR (UNIVERSITY OF ALASKA ANCHORAGE/NSF'S NOIRLAB)/M. ZAMANI (NSF'S NOIRLAB) & D. DE MARTIN (NSF'S NOIRLAB), NASA/GSFC/SDO



## △ The young ones

**NICHOLAS U MAYALL TELESCOPE, 4 JANUARY 2023**

Near the centre of this image is a star called HP Tau. It's not yet on the main sequence, and astronomers class it as a T Tauri, a young, chaotic star less than 10 million years old that is still contracting after its birth. Located around 550 lightyears away in Taurus, HP Tau is part of a triple-star system, with all three surrounded by a large reflection nebula.

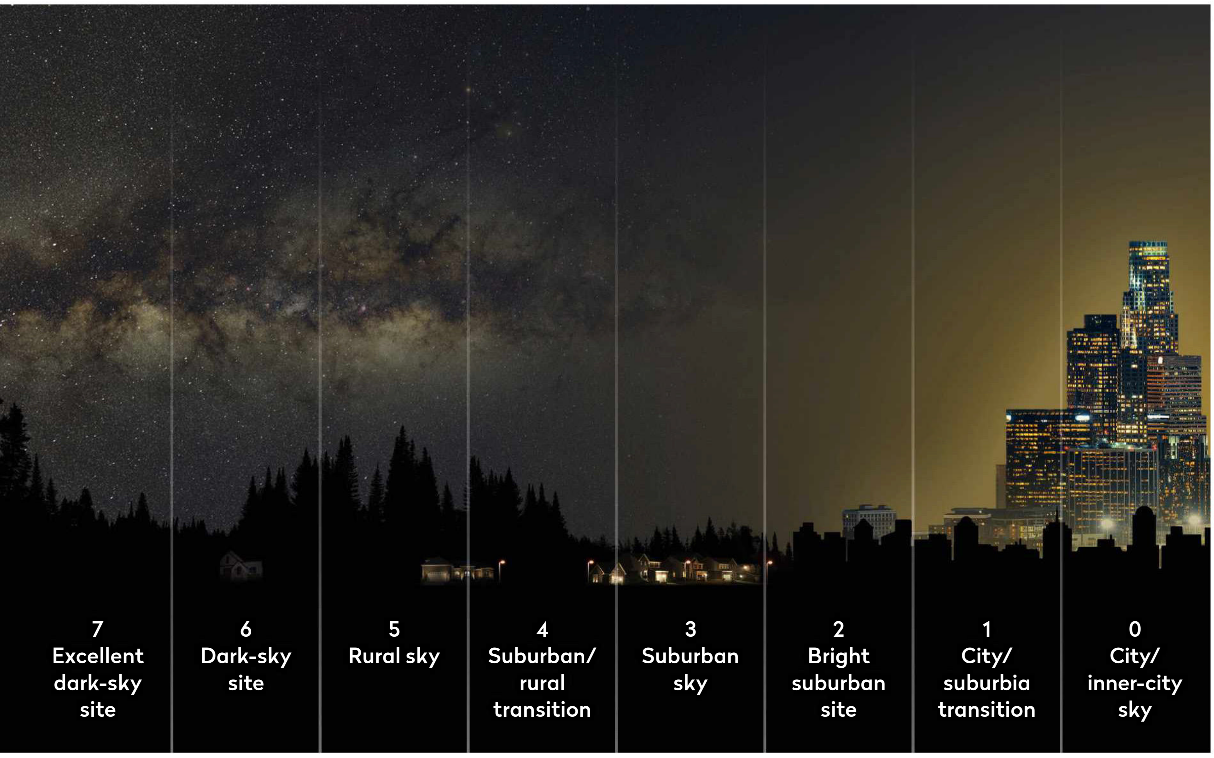
## ◁ Vanity flare

**SOLAR DYNAMICS OBSERVATORY, 9 JANUARY 2023**

At just before 7pm on 9 January, the Sun released a powerful X-class flare. NASA's Solar Dynamics Observatory witnessed the whole thing and captured this picture showing the flare on the Sun's left edge. Although it wasn't pointed at Earth, the flare nonetheless caused a slight shortwave radio blackout over the Pacific Ocean. The Sun has continued to produce such eruptions, with coronal mass ejections coming close to Earth at the end of January.

The latest astronomy and space news, written by Ezzy Pearson

# BULLETIN




▲ The sky-ranking scale used in the study revealed that artificial lights are erasing stars at an alarming rate

NOIRLAB/NSF/AURA, P. MARENFELD

## Significant rise in light pollution

Number of stars visible by eye has dropped by 10 per cent in a decade

**The stars are** disappearing from the night sky at a much higher rate than has been previously measured by satellites, according to a decade's worth of measurements gathered by members of the public and analysed by scientists.

The Globe at Night programme run by NOIRLab has been gathering measurements from citizen scientists around the world since 2006. The project asks them to compare their view of the night sky to that shown on star charts, to give a rough estimate of the limiting magnitude at their location. This latest report found that in the period between 2011 and 2022, the average number of visible stars dropped by almost 10 per cent.

"At this rate of change, a child born in a location where 250 stars were visible would be able to see only about 100 by the time they turned 18," says Christopher Kyba, one of the researchers at the GFZ German Research Centre for Geosciences that is leading this latest analysis.

This was significantly higher than the 2 per cent drop measured by satellites, partly because they are unable to measure the full extent of skyglow, the diffuse illumination of the night sky by light pollution, which is apparent from the ground. No current satellite can measure skyglow at wavelengths shorter than 500nm – yet this blue light contributes disproportionately to skyglow as it scatters more in the atmosphere. In addition, increasingly common outdoor white LED lights peak between 400 and 500nm.

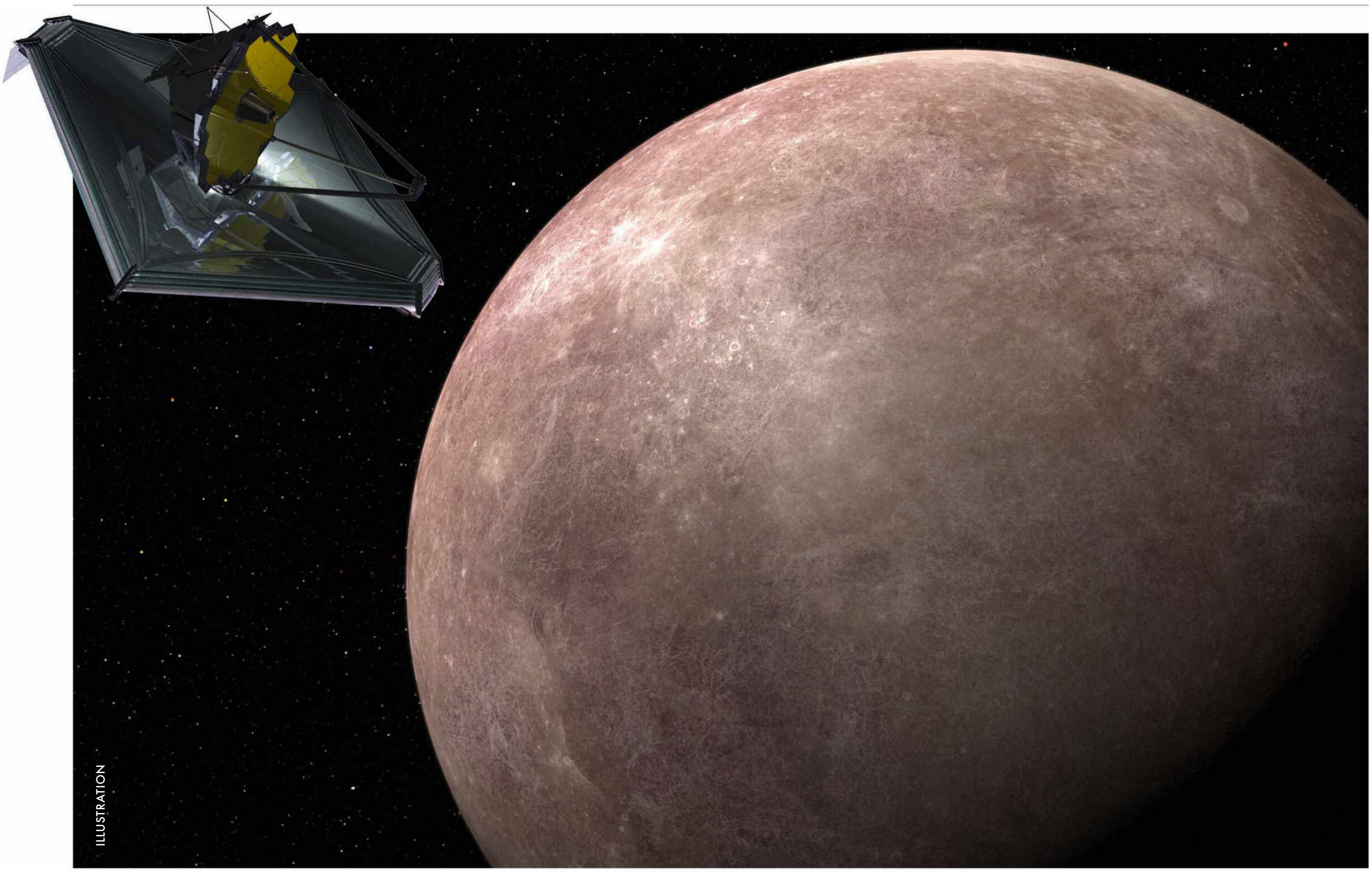
"Since human eyes are more sensitive to these shorter wavelengths at nighttime, LED lights have a strong effect on our perception of sky brightness," says Kyba. "Existing satellites aren't sufficient to study how Earth's night is changing. That shows that Globe at Night isn't just an interesting outreach activity, it's an essential measurement of one of Earth's environmental variables."
**www.globeatnight.org**

### Comment
**by Chris Lintott**

I feel surprisingly optimistic about this news story. Of course it's unequivocally bad that light pollution is getting worse. So why am I cheerful? Because while I knew the switch to LED lights had made a big difference, I hadn't realised things were getting this bad, this fast. Light pollution can seem an intractable problem, but if things can get worse fast, they can also improve rapidly.

We just need to persuade our neighbours, businesses and local politicians to make sure that the changes from now on are in the direction of responsible, careful lights, shining where they are needed, and not where they aren't – up into the night sky.

**Chris Lintott co-presents *The Sky at Night***




▲ **Artist's impression of the new, rocky planet, which whizzes around its star in two days, far faster than any planet in the Solar System**

NASA/ESA/CSA/L. HUSTAK (STSCI), ESA/NASA, CHAKRABORTY & ROY/NCRA-TIFR/GMRT, CNSA/HANDOUT VIA XINHUA

# JWST confirms its first exoplanet

## New world is almost exactly the same size as Earth

**A new era** of exoplanet exploration could be about to begin after the James Webb Space Telescope has confirmed its first exoplanet. The world, LHS 475 b, is located 41 lightyears away and is around the same size as Earth but takes just two days to orbit its star.

The planet was initially selected from a catalogue of interesting targets discovered by NASA's Transiting Exoplanet Survey Satellite (TESS) that hinted at the presence of a small, rocky world. Previous efforts have concentrated on targeting planets larger than Jupiter, as most telescopes are unable to observe smaller planets in detail. But JWST's Near-Infrared Spectrograph is sensitive enough to make out the tiny dip in light caused by the planet passing in front of its host star. The observations confirmed the planet's presence and measured it to be 99 per cent the size of Earth.

LHS 475 b is incredibly close to its host star, travelling around it in just two days. Fortunately, the star is a red dwarf. These stars have surface temperatures half that of our Sun as well as being dimmer, making it easier to measure the dip in light from a transiting exoplanet. JWST's measurements found the planet was still a few hundred degrees warmer than Earth, meaning it could potentially host an atmosphere. However, these first observations were unable to conclusively confirm if an atmosphere was present.

"There are some terrestrial-type atmospheres that we can rule out," says Jacob Lustig-Yaeger from Johns Hopkins University, who co-leads the study. "It can't have a thick methane-dominated atmosphere, similar to that of Saturn's moon Titan."

It is possible that the planet has a carbon dioxide atmosphere, similar to Venus. "Counterintuitively, a 100% carbon dioxide atmosphere is so much more compact that it becomes very challenging to detect," says Lustig-Yaeger.

The team has already secured additional observing time this summer to obtain more spectra, which will hopefully allow them to distinguish between a planet with a pure carbon dioxide atmosphere and no atmosphere at all.

"We're at the forefront of studying small, rocky exoplanets," says Lustig-Yaeger. "We have barely begun scratching the surface of what their atmospheres might be like."

**www.webbtelescope.org**

Peake spent six months conducting science experiments on the ISS in 2015–2016

# Tim Peake retires from active duty

The astronaut will dedicate his time to outreach and education

**Tim Peake, the** UK's first ESA astronaut, has announced he is stepping down from active duties to take on a new role as an ambassador for ESA activities and promoting science careers to young people.

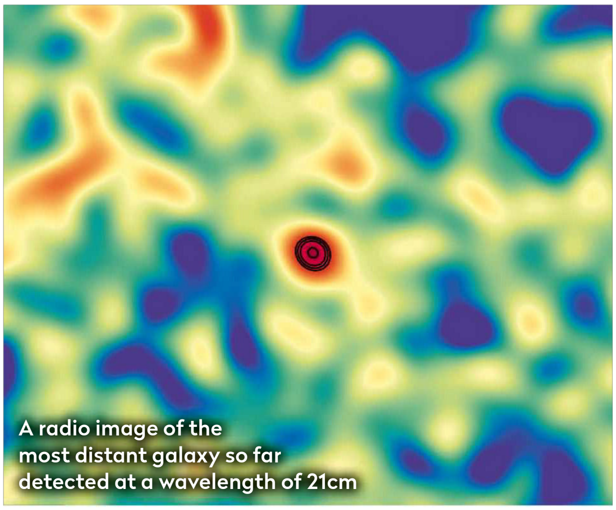
"Being an ESA astronaut has been the most extraordinary experience," says Tim. "I have had the privilege of working with an exceptional team of dedicated individuals during the past 13 years with the agency, which has been incredibly exciting and rewarding."

Peake was part of ESA's 2009 astronaut class, spending six months on board the International Space Station in 2015 and 2016, during which more than two million children engaged in educational programmes linked to his Principia mission. He took a sabbatical from ESA in October 2019 to focus on outreach while remaining eligible for a future flight. However, after two years Peake has decided to take on his educational role permanently.

**www.esa.int**

# Distant radio galaxy observed for the first time

**Astronomers have detected** radio signals from a galaxy that have been travelling for 8.8 billion years, making it the most distant galaxy ever recorded at these wavelenghts. The detection was made using the Giant Metrewave Radio Telescope in India, which looked for the 21cm line, a wavelength emitted by hydrogen gas and a key observation when investigating how stars form in other galaxies.


A radio image of the most distant galaxy so far detected at a wavelength of 21cm

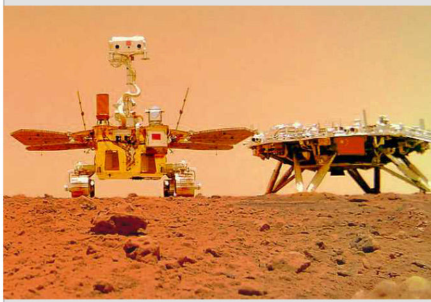
"Until now, it's only been possible to capture this particular signal from galaxies nearby, limiting our knowledge to those galaxies closer to Earth," says Arnab Chakraborty from McGill University, who led the research.

Fortunately, nature lent a helping hand with a phenomenon called gravitational lensing, where a massive galaxy or cluster bends the light from a distant object, acting like a lens and magnifying the light. This allowed Chakraborty and his team to observe galaxy SDSSJ0826+5630, the light from which left it when the Universe was just 4.9 billion years old, offering a glimpse into the early Universe.

"This will help us understand the composition of galaxies at much greater distances from Earth," says Chakraborty.

**www.gmrt.ncra.tifr.res.in**

# NEWS IN BRIEF



## Chinese rover fails to wake

China's Zhurong Mars rover was supposed to wake up from its winter hibernation at the end of 2022 but has failed to make contact with Earth. The problem is likely to be dust on the solar panels preventing them from charging, though it is possible the rover could reestablish contact as the planet continues to warm up.

## Early opening for barred galaxies

Barred spiral galaxies like our own Galaxy – where the central regions are stretched out into bars – existed when the Universe was just three billion years old, according to JWST observations. The bars feed gas into the centre of galaxies, so tracking them through cosmic history is vital to understanding how galaxies grow.

## Planet spirals to its doom

A planet spiralling towards its star has been found for the first time, offering a window into Earth's future when the Sun reaches the end of its life. The planet, Kepler-1658b, is about the size of Jupiter and will collide with its star in less than three million years.

# NEWS IN BRIEF

### Failure to launch

The first space launch from UK soil ended in failure on 9 January. The Virgin Orbit flight took off from Spaceport Cornwall at 10pm and climbed to 35,000ft. Once at altitude, it dropped the LauncherOne rocket, which experienced an anomaly with its second stage, resulting in the rocket's failure to reach orbit.

### Flare warning

Bright but tiny flashes on the Sun's surface could help astronomers predict when the next solar flare is about to erupt. Data from NASA's Solar Dynamics Observatory revealed that just before the Sun produced a flare, there were small-scale flashes in the upper atmosphere above where the release was about to take place.

### Ryugu's ancient start

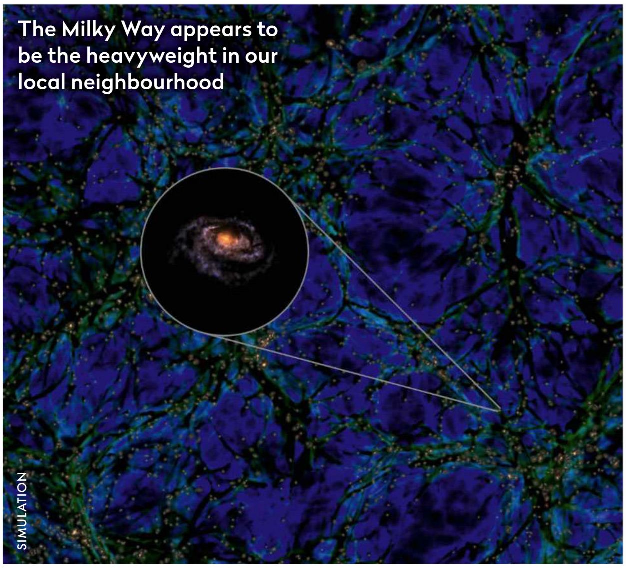
Carbonate minerals found in samples from asteroid Ryugu are millions of years older than previously thought. The samples brought back by the Hayabusa 2 craft suggest water interacted with rock very early in our Solar System, with temperatures dropping low enough for water to remain liquid earlier than initially believed.

VIRGIN ORBIT, IMAGES: MIGUEL A. ARAGON-CALVO,/SIMULATION DATA: ILLUSTRIS TNG PROJECT, ALMA (ESO/NAOJ/NRAO); M. WEISS (NRAO/AUI/NSF

BULLETIN

# Milky Way is special after all

## Simulations suggest our Galaxy is surprisingly massive



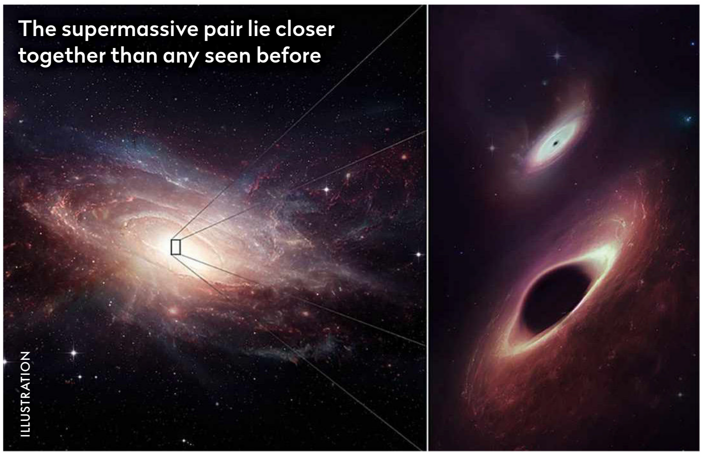

The Milky Way appears to be the heavyweight in our local neighbourhood

**The Milky Way** is one in a million, according to a recent set of simulations. Our Galaxy is part of the Local Sheet, a cosmological wall of galaxies on the edge of a large void. New simulations from the IllustrisTNG Project have shown that elsewhere in the Universe, galaxies in these walls tend to be smaller than the Milky Way. In fact, only one in every million is as large as our own.

"What we newly found is that other walls of galaxies in the Universe like the Local Sheet very seldom seem to have a galaxy inside them that's as massive as the Milky Way," says Joe Silk from Sorbonne University's Institut d'Astrophysique de Paris, who took part in the study. "[But] if you could see the nearest dozen or so large galaxies easily in the sky, you would see that they all nearly lie on a ring, embedded in the Local Sheet. That's a little bit special in itself."

**www.tng-project.org**

# Close black holes lie side by side




The supermassive pair lie closer together than any seen before

**A pair of** black holes have been discovered that are closer together than any pair previously observed in multiple wavelengths, a new report has revealed. They are in the heart of a galactic merger, UGC 4211, which has an active galactic nucleus, meaning its central black hole heats up the surrounding gas. When astronomers viewed the galaxy using the Atacama Large Millimeter/Submillimeter Array (ALMA), however, they found not one, but two black holes just 750 lightyears apart. The find led to an observing campaign using telescopes across the electromagnetic spectrum.

"Each wavelength [reveals] a different part of the story," says Ezequiel Treister from Universidad Católica de Chile, who took part in the research. "While ground-based optical imaging showed us the whole merging galaxy, Hubble showed us the nuclear regions at high resolutions. X-ray observations revealed that there was at least one active galactic nucleus in the system. All of these data together have given us a clearer picture of how galaxies such as our own turned out to be the way they are, and what they will become in the future."

**www.almaobservatory.org**

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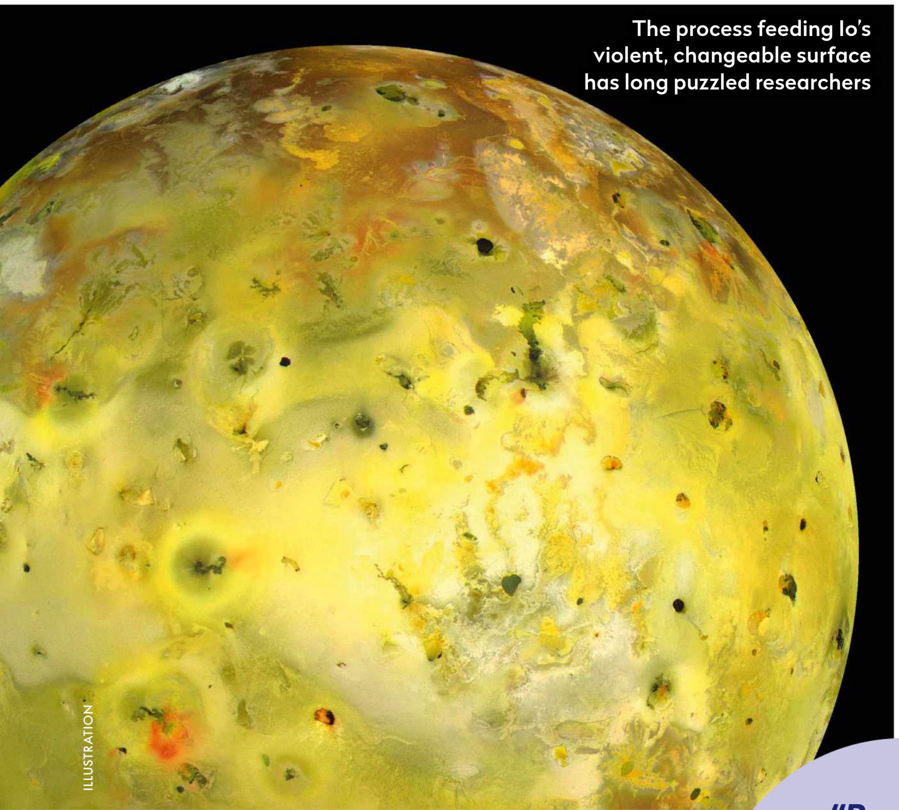
# CUTTING EDGE




The process feeding Io's violent, changeable surface has long puzzled researchers

NASA/JPL/UNIVERSITY OF ARIZONA, ZWICKY TRANSIENT FACILITY

## Io's molten heart

### Jupiter's moon probably has a magma ocean, rather than a spongy centre

The moon Io, the innermost Galilean satellite of Jupiter, is a violent, tortured little world. Despite being almost the same size as our own Moon, the two couldn't be more different. Our Moon is a cold, dead world, while Io is the most volcanically active body in the Solar System – even more so than Earth – and is constantly spewing itself inside out with intense eruptions.

The driving force behind all this activity is tidal heating. The powerful gravitational pull of Jupiter tugging on Io constantly distorts its shape. This perpetual bending and flexing generates intense tidal heating in the interior of the moon, melting its silicate rock crust into hot magma. Normally, tidal effects would dissipate as the moon's orbit becomes more circular over time, and its rotation becomes locked to its orbital period. But in Io's case, the gravitational effects of the other Galilean moons keep nudging it into an elliptical orbit, maintaining this fierce tidal heating so that its volcanism has persisted for billions of years.

What's not well understood, however, is exactly how much magma melt there is below the surface, or what form it takes. This is important because it affects the dissipation of tidal heating, which is a key part in understanding Io's surface features. Recently, a reanalysis of 1990s data from the Galileo probe's magnetometer instrument has suggested that Io could have a global layer of largely molten rock at least 50km-thick underground. But does this exist as a complete magma ocean, or is it more like a 'magmatic sponge', with an interconnected network of solid rock soaked through with liquid magma?

Yoshinori Miyazaki and David Stevenson, both at Caltech in Pasadena, California, have built a computer model to study different possibilities for Io's subsurface magma, as well as different degrees of tidal heating. Their results indicate that the amount of tidal heating within Io is probably insufficient to maintain a spongey structure of interconnected solid rock bathed in molten magma. Such a composition would rapidly separate into two distinct layers: a magma ocean floating on top of a mostly solid shell. Since tidal dissipation acts much more effectively on the rigid characteristic of solids, this lower layer experiences most of the heating and keeps the ocean above it liquid (although Miyazaki and Stevenson note that the magma ocean need not be pure liquid – it's likely to contain some degree of solidified crystals). The magma ocean then transports that internal heat up to Io's surface, feeding its many volcanoes.

***"Does this 50km-thick molten rock layer exist as a complete magma ocean, or is it more like a magmatic sponge?"***

Miyazaki and Stevenson have shown that if the hypothesis of a melt-rich layer in Io's subsurface is correct, it should exist as a magma ocean rather than a magmatic sponge. And we may not have long to wait to find out for sure. The Juno mission is currently exploring the Jovian system, and through its fly-bys of Io will be able to measure the rigidity of the moon's crust. This will provide vital information on the details of a melt-rich layer in the subsurface.

**Prof Lewis Dartnell** is an astrobiologist at the University of Westminster

**Lewis Dartnell** was reading… *A Subsurface Magma Ocean on Io: Exploring the Steady State of Partially Molten Planetary Bodies* by Yoshinori Miyazaki and David J Stevenson
**Read it online at: arxiv.org/abs/2211.06945**

# Ancient explosion was a rare supernova

## Astronomers have puzzled over the bright event for centuries

**Prof Chris Lintott** is an astrophysicist and co-presenter on *The Sky at Night*

Over 840 years ago, in August 1181, Chinese and Japanese astronomers saw a new star suddenly appear that remained visible for 180 days. We now know this was the violent death of a massive star, a supernova, and the 1181 event is one of only a handful to ever have been seen with the naked eye.

Now astronomers have started looking at the site of the supernova, in the modern constellation of Cassiopeia, in the hope of finding a remnant. Radio searches, which attempted to uncover a pulsar, failed to find anything suitable, but citizen scientist Dana Patchick, combing through data from numerous earthbound surveys, as well as the infrared WISE satellite, found an unusual circular nebula which surrounds a bright central star around 8,000 lightyears from Earth.

Studies of this new object have shown that the bright region is a shell of gas expanding at a rate of more than 1,000km per second. Projecting backwards, this gives an age for the object of nearly a thousand years, fitting perfectly with the recorded supernova. Another new paper, with deep images of the nebula, shows its structure, with filaments pointing away from the central star, which must therefore be the source of the gas.

But if this is a supernova remnant, then what is the central star? A supernova should produce a dense neutron star, or a black hole. But neither of those should shine brightly, whereas this observed star is more than four times as luminous as the Sun. It's detected not only in the infrared, but also in ultraviolet and in X-ray observations, which reveal a temperature of 200,000° Celsius. Spectra tell us that it is made of (mostly) carbon and oxygen, with none of the hydrogen and helium that accounts for most of the mass in the Sun and other main sequence stars.

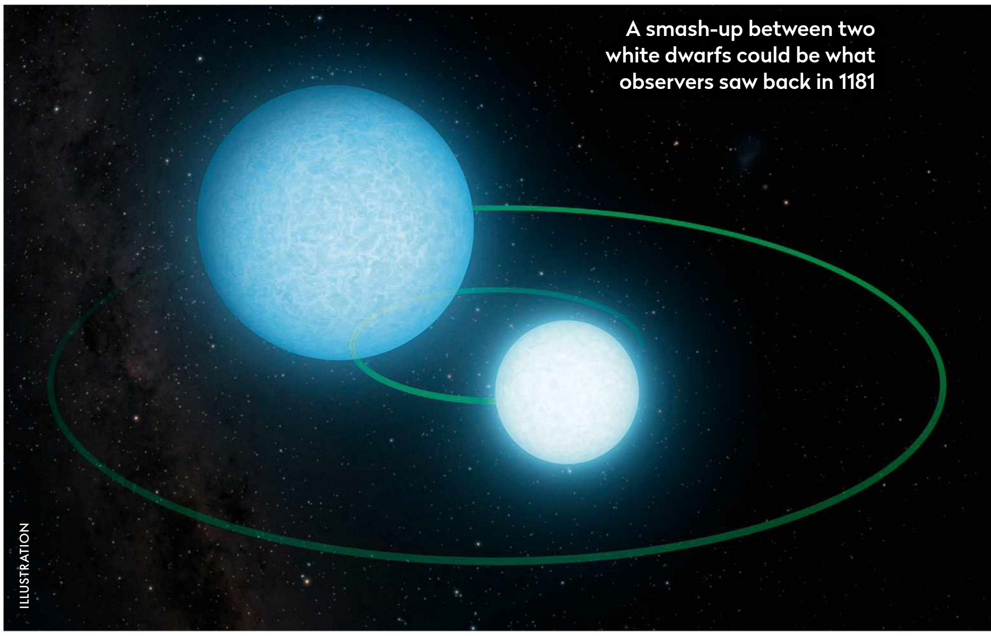
**"In a Type Iax, both stars are white dwarfs, and the supernova is produced when the two collide and merge with each other"**

It looks, in fact, like a hot white dwarf, but such objects are normally formed from the death of stars far less massive than those that go supernova. The paper by Bradley Schaefer resolves this conundrum by claiming the 1181 event was an example of a little-understood, rare class of supernova: a Type Iax.

Type Ia supernovae are typically caused by the interaction of a white dwarf with a binary companion. In a normal Type Ia, the white dwarf steals matter from an orbiting normal star until this piled-up material ignites, blowing the host dwarf apart. In a Type Iax, both stars involved are white dwarfs, and the supernova is produced when the two collide and merge with each other.

In this case, it seems we can explain everything that's been observed if we invoke a collision between two white dwarfs, one rich in carbon and oxygen, and the second in oxygen and neon. Crucially, such an event would have left only a single central star with no companion, exactly as observed.

If this is the end of the search for the ancient supernova's remnant, it will be the beginning of a new scientific quest. This is only the fifth time we have found the remnant of a supernova that was also seen in the sky, and it may help us understand these rare and spectacular events.



ILLUSTRATION

**A smash-up between two white dwarfs could be what observers saw back in 1181**

**Chris Lintott** was reading... *The Path from the Chinese and Japanese Observations of Supernova 1181 AD, to a Type Iax Supernova, to the Merger of CO and ONe White Dwarfs* by Bradley E Schaefer **Read it online at: arxiv.org/abs/2301.04807**

# INSIDE THE SKY AT NIGHT

On the 100th anniversary of Patrick Moore's birth, **Chris Lintott** remembers the time they spent together on the set of *The Sky at Night*

Chris and Patrick at Farthings, where much of the show was latterly shot

A decade has passed since we made a show with Patrick. It's hard to believe that it's been so long. While his spirit and ideas, and particularly his determination that we should try to explain everything we can as simply and plainly as possible, still inspire us each month, I have to confess that I miss the anarchic fun that he brought to the whole process of making *The Sky at Night*.

Though my first couple of encounters with Patrick on the programme were in the studio, tucked away in the corner of BBC Television Centre's enormous Studio 1, by the time I joined the show as a researcher and then reporter, its heart was the study of Patrick's beloved home in Selsey, Farthings. Guests would travel down and stay over, making the dinner table (replete with food provided by the local pub) the site of the world's best and most convivial astronomical tutorial. I wish we'd recorded some of those chats, which were often three or four hours long; in the era of podcasts, they would be great bonus content!

I learnt an enormous amount from those evenings, both about astronomy, but also about how to communicate. Patrick would be having a thoroughly sociable time, but then suddenly interrupt to make sure that he understood a particular point, or to express his scepticism at some modern theory ("Dark matter? Well, I suppose it's okay…", he would chunter). All of it went into making the next day's conversation, on camera, flow as easily as possible, and more than one guest was surprised to find their choice description of some phenomenon or other now firmly installed in Patrick's opening monologue.


▲ Chris, Brian May and Patrick in his garden in Selsey, filming an episode observing the transit of Venus on 8 June 2004

## Fun times at Farthings

Some of my favourite programmes were the times when we could open up the rest of Farthings and use the observatories in the garden. We hosted several *Sky at Night* star parties, where guests like Terry Pratchett – who brought his own bat detector, for some reason – could rub shoulders with astrophotographers and amateur astronomers of all stripes. It was an exhausting way to make a programme, with the long-suffering crew dealing with what now seems like very primitive night-vision equipment out in the cold for hours and hours. But we'd always come inside to find Patrick, his on-camera duties done, holding court until dawn, telling stories to others who had retreated inside.

**Prof Chris Lintott** is an astrophysicist and co-presenter on *The Sky at Night*

As Patrick could travel less and less, he was extraordinarily generous with the programme, insisting it was important the show got about, even if he couldn't. We did manage some trips though. I vividly remember him in an enormous orange boiler suit, chatting away to everyone as we descended in a lift to the UK's dark matter experiment in Boulby Mine.

And there was also a last trip to Jodrell Bank to interview its director and inspiration, the late, great Bernard Lovell. The two old friends chatted for the camera in front of the giant dish, now named after Lovell, until it began to rain. As we rushed to finish, each was solicitous in explaining that while they, despite their advancing years, were fine, it might be a good idea to get the elderly gentleman opposite into the warm.

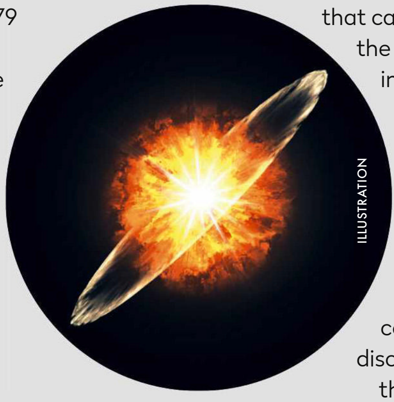
Patrick was often frustrated by the show. His idea of a perfect programme would usually be a 20-minute monologue, delivered with monocle in place, straight to camera, and as technology and television advanced, producers and audiences expected rather more. What he was always proud of, though, was that *The Sky at Night* didn't ever waver from its original idea: to tell everyone what we know about space, and the night sky above our head, as clearly and simply as possible. He did it like no one else could.

## Looking back: The Sky at Night

### 4 April 1979

Back on the 4 April 1979 episode of *The Sky at Night*, Patrick took the time to look not at the stars but the seemingly empty space between them. While this might look like an empty void, it is actually filled with a cocktail of gases.

Early astronomers believed space was filled with 'aether', a hypothetical substance they thought light travelled through. It wasn't until 1904 that the first signs of gas were detected by Johannes Hartmann while he was observing the binary star Delta Orionis. Hartmann noticed that while most of the spectral lines created by elements within the star broadened and shifted as the stars rapidly orbited each other, the calcium lines remained steady. He concluded that calcium wasn't within the star's atmosphere, but in the space between.




▲ Gases are flung out into the cosmos by supernovae

Over the years, more elements were discovered between the stars. The first molecule was discovered in 1937, with increasingly complicated ones discovered in the years that followed, including several organic chemicals – the building blocks of life.

All of these various elements, however, originated within the stars themselves. While some gas escapes the star's gravity via stellar winds, most is thrown out into the cosmos during supernovae. Over millions of years this gas drifts through the cosmos, forming clouds and structures that form the most visible sign of the interstellar medium – nebulae.

BBC iPLAYER

## Searching Space

The *Sky at Night* team are taking a break this month, but will be back on our screens in April. In the meantime, explore some of the latest space science and astronomy with the Searching Space collection on the BBC iPlayer. *The New Space Race* takes a fascinating look at emerging private spaceflight companies, while *Cosmic Hunters* reveals the new technologies helping astronomers unlock the secrets of the Universe, and *Return to the Moon* explores NASA's Artemis and the plans to once again put humans on the lunar surface.

**www.bbc.co.uk/programmes/p0dpfs4l**

▲ Find out about the future of spaceflight and astronomy on the BBC iPlayer

# INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

**MESSAGE OF THE MONTH**

This month's top prize: two Philip's titles


The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2023* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

## Off to a great start

I just wanted to share with you my first deep-sky astrophoto, which I took by following the excellent guide to photographing the Orion Nebula with a DSLR camera on your website, written by Pete Lawrence and David Tolliday (bit.ly/M42DSLR). The exposure time and ISO settings advice was very useful. I used a WideSky 80S ED refractor telescope on a Sky-Watcher Star Adventurer GTi mount, with a Canon EOS 2000D DSLR camera and the images were stacked in DeepSkyStacker. As I have zero knowledge of Photoshop, I just messed around with it until I got an image I was happy with! Astrophotography seemed daunting to me, but I put the Orion Nebula at the top of my list of goals for this year. To capture it in my first 'proper' attempt means I'll be out every clear night snapping away! Please pass my thanks on to Pete and David.

**Paul Ritchie, Stockton-on-Tees**

A fantastic first effort from Paul – the splendid Orion Nebula

Congratulations on ticking off one of your New Year resolutions so early in the year, Paul! Keep an eye on the magazine and website for more imaging advice. ***– Ed.***

## Tweet

**Tim Burgess**
@TimBurgess • 23 January

The #Moon, #Venus and #Saturn in conjunction this evening. Super clear skies with some lovely sunset hues there too. #astro #astrophotography #planets #conjunction @VirtualAstro @skyatnightmag

Roger followed in his hero's footsteps to catch this comet

## Glaze of glory

George Alcock (1912–2000) was the finder of five comets and five novae and has been described as the greatest visual astronomer who ever lived under cloudy UK skies. Comet IRAS–Araki–Alcock was the brightest comet he had a share in discovering, and the fact he did so with hand-held binoculars, from indoors looking through a window, just adds to his legendary status. George's final discovery, Nova V838 Herculis, was made on 25 March 1991 when he was 78 years old, and he was, once again, observing from indoors through a double-glazed window using 10x50 binoculars. I'm now 76 and, inspired by George, have been imaging objects for several years – again, like George, from indoors through double-glazed windows. So it seems appropriate that I imaged comet C/2022 E3 ZTF in this way. There is much light pollution here in the direction of the rising comet, so the small loss of light through the glazing is not that significant.

**Roger Samworth, Nuneaton**

## Scope from scrap

As well as my astronomy activities, I'm a member of an amateur opera society here in the South West, the Somerset Opera. We've just finished a touring production,

The rather impressive prop telescope that Harold built from odds and ends

a modern-day version of Menotti's *Amahl and the Night Visitors*. One stage prop we needed for this was a telescope, as in one scene Amahl scans the heavens, obviously looking at the star of Bethlehem! For a few milliseconds I considered lending my own apo refractor, but common sense soon prevailed and I made one instead. The tube was the centre of a roll of clingfilm, the right-angled draw tube toilet roll cores. For the focuser knobs I used screw-on caps from fruit juice bottles and a plank I found in my workshop, sawn into strips, became the tripod and altaz mount. I made the 2-inch eyepiece out of the trim from a broken door handle, the dew shield from layers of black duct tape, and the finderscope out of a plastic broom handle. With a lick of white paint and woodstain, from the audience's view I think it looked great, and there was no risk of very expensive damage to my kit!

**Harold Mead, Taunton**

## Name game

I saw the comet E3 ZTF for the first time through the light pollution last night, using just a pair of 8x60 astronomical binoculars and averted ▶

## ON FACEBOOK

**WE ASKED: Why is Venus known as the Morning or Evening Star?**

**Andrew Ladzinski** Because it is an inner planet from us. Its orbit doesn't go out far enough to make it visible at other times.

**Ahmad Mohammed** Because when it is visible, it is either in the eastern morning sky or the western evening sky.

**Everton Johnson** The morning star and evening star is not a star, it's a planet.

**Gene Rodriguez** Because it is so bright and it's a beautiful planet too!

**Linda Stubbs** At her brightest, when she is most red, she is a lovely sight.

**Janice Burdett** One thing I loved in school was our planets. I have a passion for Venus and all planets.

**Jack Eastman** In 2020 I heard a boy on the phone when I was walking the dog. He said he saw a wishing star early evening. It was way too bright to be a star. I told the dog it was Venus. It will not work to wish on a planet.

**George Pepperrell** I observed the transit of Venus back in 2005. A few years later it was cloudy so I couldn't see it. It won't do that again for another 150 years.

# SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

### *Is there a way to attach large astronomical binoculars, such as those made by APM, to an equatorial mount?*

**ALAN HOLT**

GRAHAM GREEN

▲ A parallelogram mount tailor-made for binoculars is a good mounting option

Large binoculars like those manufactured by APM can physically be attached to an equatorial mount by first attaching a dovetail bar to the binocular's tripod adaptor using a ¼–20 bolt from the underside of the bar, and then attaching the bar to the dovetail clamp on the equatorial mount.

However, this would absolutely not be recommended. An equatorial mount moves in an arc as it tracks objects across the sky, so the binoculars would spend most of their time at an awkward angle and at varying heights from the ground. The eyepieces would be positioned anywhere from vertically above one another to horizontal, depending on which part of the sky you are observing, making the binoculars pretty much unusable.

An altaz mount, on the other hand, moves only left–right and up–down, so the binoculars' eyepieces would remain horizontal and placed above the centre of the mount at all times, making this the mount of choice. Alternatively, consider a parallelogram mount designed specifically for binoculars.

## *Steve's top tip*

### *What is an OTA?*

Like so many pursuits, especially those involving science and specialised equipment, astronomy has its own language and abbreviations ,which can be confusing for beginners.

A frequently used abbreviation is 'OTA'. It stands for Optical Tube Assembly and refers to the main part of a telescope that supports the mirrors in a reflector telescope like a Newtonian, Schmidt-Cassegrain telescope (SCT), Maksutov (Mak) or Ritchey-Chrétien (RC); or the lens elements in a refractor. The focuser and accessories like finderscopes, red dot finders and dovetail bars or tube rings also attach to the OTA.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

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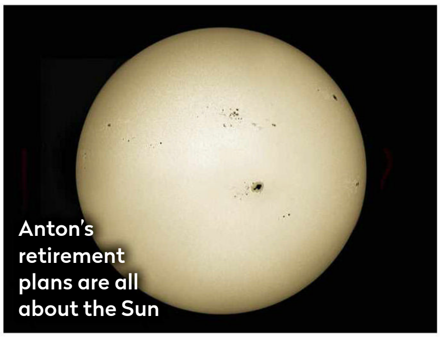
## Instagram

**timwhite111 • 24 January**

Comet C/2022 E3 ZTF imaged with ZWO ASI2600MC and RedCat 51 #redcat51 #comet #zwo #deepspace #astronomy #nasa #astrophotography #greencomet #space #stargazing @bbcskyatnightmag @yourastronomy @zwoasi

▶ vision. I think a comet as beautiful as this deserves a name. As it is green and well-liked, after some thought I have named it 'Shrek' after the well-loved cartoon character. I have yet to contact the Zwicky Transient Facility about this.
**David Wright, via email**



Anton's retirement plans are all about the Sun

## Sun and games

Solar cycle 25 has coincided with my early retirement from teaching. So now when the Sun shines I am ready to take advantage of the good weather. For a change I took this white-light image of the Sun using a Sky-Watcher Evostar 80ED refractor, a white-light filter and a ZWO ASI224MC astro camera. Over the last year, the Sun has certainly picked up its activity and I hope to document as much of the action as I can. Sol Invictus!
**Anton Matthews, via email**

## Measuring up

When distances between heavenly bodies, such as between Earth and the Moon, are stated, is this distance from centre to centre or surface to surface?
**Alan West, via email**

Generally most distances are quoted centre to centre since the size of planets and other bodies is tiny compared with distances between them. – ***Ed.***

## SOCIETY IN FOCUS

Formed in 1881, **Liverpool Astronomical Society** is one of the oldest in the world. Today, it continues to promote the science of amateur astronomy as it did over 140 years ago.

LAS struggled through lockdown, yet we kept going with virtual meetings and talks from guest speakers as far away as Canada and the USA. All that now behind us, members embraced the 2022–23 season with local outreach events and the return of monthly face-to-face meetings at the Quaker Meeting House, School Lane, Liverpool.

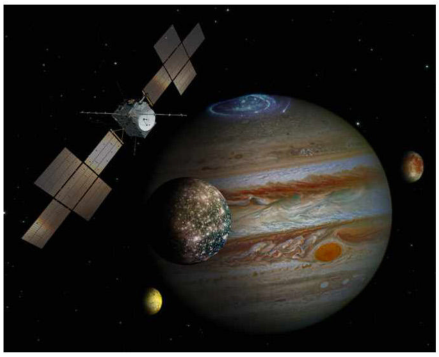
In March 2023 our very own Rob Johnson will be talking about astrophotography, and in April Dr Mark Norris from the University of Central Lancashire will discuss cosmology. The reopening of our Pex Hill Observatory has been very popular, enabling visits from Cubs and Scouts groups, and the restart of our Young Astronomers Club.

▲ The society's trip to Pex Hill Observatory to see the solar eclipse, 25 October 2022

Our big recent event was 'When NASA Went to the Moon', at Liverpool's Central Library and World Museum, celebrating the 50th anniversary of Apollo 17. We had fascinating talks, memorabilia displays and experts on hand. Hundreds of visitors came, despite the snow. It's safe to say our society is thriving again and, with almost 200 members and plenty of newcomers, we're in good shape for the future.
**Steve Southern, President, Liverpool AS**
▶ www.liverpoolas.org

We pick the best live and virtual astronomy events and resources this month

# WHAT'S ON



### JUICE and the Icy Moons of Jupiter

**School of Physics and Astronomy, Cardiff University, 2 March, 7:30pm**

A talk by Prof David Southwood on ESA's Jupiter Icy Moons Explorer (JUICE) mission which is scheduled to launch this April and to reach Jupiter in July 2031. Booking not required. **www.cardiff-astronomical-society.co.uk**

### Practical Astronomy Show

**Kettering Conference Centre, Northamptonshire, 11 March**

This show brings together astronomy businesses, organisations and educational institutions, with free talks and an emphasis on using and getting the best out of astronomy products. Free entry. **practicalastroshow.com**

### Spring Stars and Galaxies Far Away!

**Sutton Bank National Park Centre, Thirsk, North Yorkshire, 11 March, 7:30pm**

Taking advantage of the new Moon, experienced astronomer Richard Dern offers telescopes and binoculars to unlock the sky's treasures in this beginner-friendly event. Tickets from £11. **bit.ly/3il37oE**

### Celestial Stones of the Equinox

**St Ives Library, Cornwall, 15 March, 7pm**

A talk from archaeoastronomer and author Carolyn Kennett on how ancient communities connected with the skies above Cornwall, and the special relationship prehistoric sites have with the equinoxes. Tickets from £7. **stives.ticketsolve.com**

## PICK OF THE MONTH

▲ Northern lights: stargazing and performing arts meet on the Western Isles

### Hebridean Dark Skies Festival

**Various venues, Isle of Lewis, Outer Hebrides, 9–21 March**

This ambitious annual festival includes live music, films, visual arts and theatre performances alongside astronomy talks, planetarium shows and stargazing. Creative workshops for children, a concert showcasing David Bowie's space-inspired songs, a talk from astrophotographer Wil Cheung about chasing the aurorae, and a new show by street theatre company Mischief La Basin in which aliens tell the stories of eight female space pioneers are among the many highlights of the jam-packed festival – and all taking place under some of the UK's darkest skies. For details, visit **lanntair.com/creative-programme/darkskies**.

### Toothill Observatory public open evening

**Southampton, 17 March, 7:30pm**

An opportunity to join Solent Amateur Astronomers to observe galaxies, nebulae and clusters through their 14-inch telescope, with other scopes and binoculars also available. Adults £5, children 50p. **www.solentastro.org**

### An Introduction to Astronomy

**Carlton Marshes Nature Reserve, Lowestoft, Suffolk, 21 March, 6:45pm**

An illustrated talk by Ian Hobson introducing astronomy and what we can see in our night sky. Adults £6. **www.suffolkwildlifetrust.org/events**

### At the Limits of Astrophysics

**Royal Institution, London, 23 March, 7pm**

Astrophysicist Katy Clough discusses some of the more exotic astrophysical objects, including wormholes and warp drives. From £7. **www.rigb.org/whats-on**

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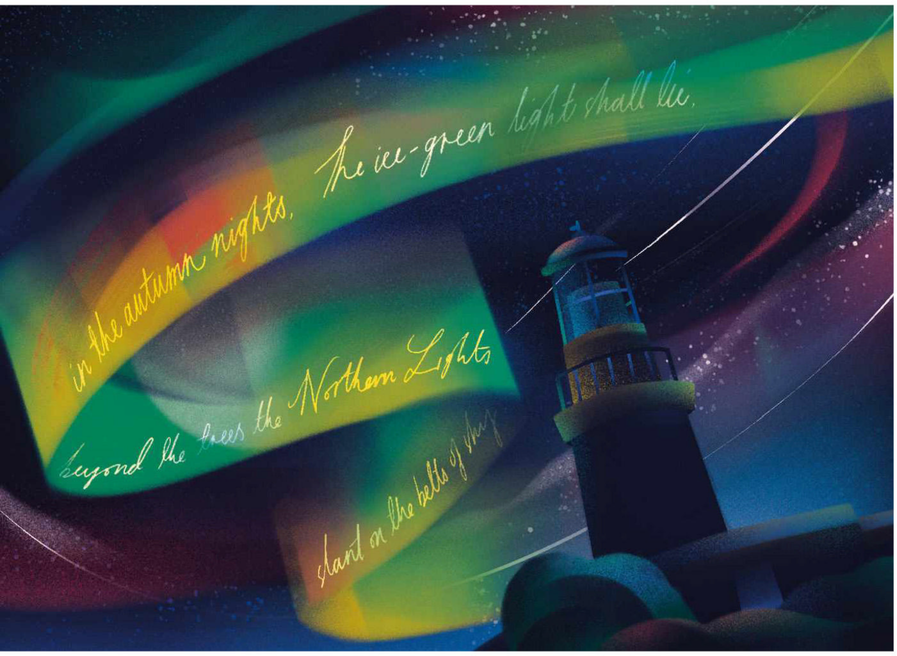
# FIELD OF VIEW

## Finding poetry in the Northern Lights

**Caroline Burrows** on the verses that captured the sky-spectacle down the ages




**Caroline Burrows** is a professional poet and writer based in Bristol who's been featured on BBC Radio 4. Follow her on social media: @VerseCycle

This winter, I'll be teaching poetry north of Inverness in Cromarty, best known for its lighthouse and as a sea area in the Shipping Forecast. Its beacon of light no longer shines, but what I hope to see at night instead are the shimmering greens, pinks and reds of the Northern Lights.

I almost saw them once when on the Isle of Lewis. My phone app alerted me to visible solar activity, so I got out of bed, went outside with my coat on over my pyjamas, and was met by a thick blanket of clouds. Mentions of the Northern Lights in poetry have proved elusive too. Nevertheless, when they appear, they span time and distance in mystical, magical or haunting settings.

I find them in 19th-century North America, where transcendentalist Walt Whitman muses on the meaning of life in his 1880 poem, 'A Riddle Song':

*Rich as a sunset on the Norway coast, the sky, the islands, and the cliffs,*
*Or midnight's silent glowing northern lights unreachable.*

I return over the Atlantic to a Scottish mother writing about the loss of life. In 'To AHJ', published in 1918, Violet Jacob describes the landscape of home, far from where her son Harry died at the Somme:

*On Angus, in the autumn nights,*
*The ice-green light shall lie,*
*Beyond the trees the Northern Lights*
*Slant on the belts of sky.*

I sail across ancient Greece's wine-dark sea after the Trojan War in Homer's epic, *The Odyssey*. Each day is lit by the dawn goddess Eos riding across the sky. But because English translations often adopted Roman gods, such as in Alexander Pope's 1726 version, I encounter Eos's counterpart Aurora:

*But when, from dewy shade emerging bright,*
*Aurora streaks the sky with orient light*

The Greeks called the north wind Boreas, but it wasn't until the Renaissance that the Northern Lights' synonym was created by Galileo, who combined *Aurora* with the Latinised *Borealis*. But those are not its only names. In Old Norse mythology it's Bifrost, a bridge to the realm of gods where Odin, Thor and Loki reside. Translated by Rasmus B Anderson in 1901, Snorri Sturluson's medieval text *The Prose Edda* reveals:

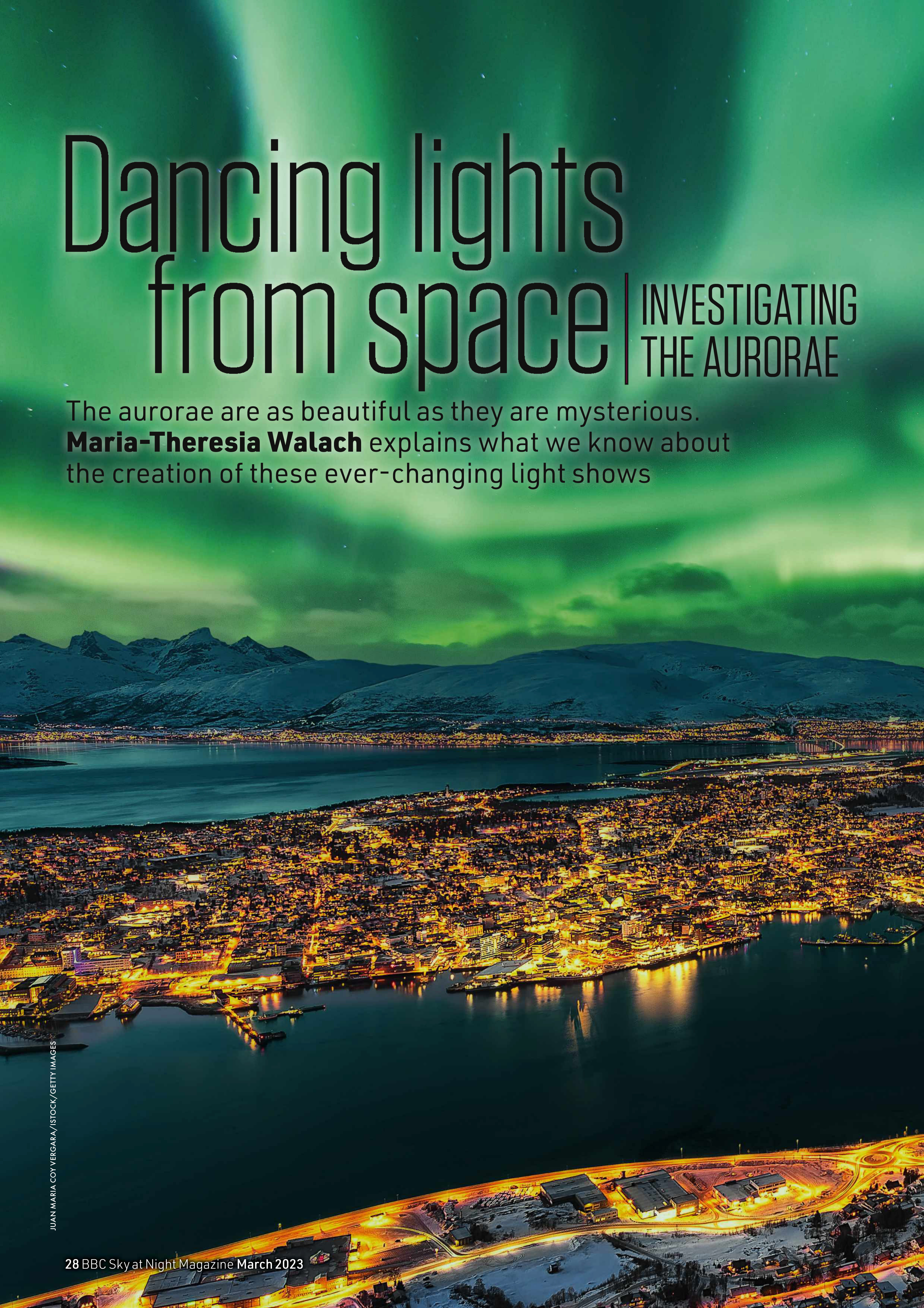
*The gods made a bridge from earth to heaven, which is called Bifrost? You must have seen it. It may be that you call it the rainbow. It has three colors*

And it's not only Nordic skies lit by mythical characters. In northern Scotland, the lights are called the Mirrie Dancers. In Scottish Gaelic they're Na Fir-Chlis, the 'nimble men', which is also the name of a 1909 poem by Donald Mackenzie. It incorporates folklore associated with the lights, in which a fairy ceilidh in the heavens turns into a conflict. I discover Mackenzie was born and buried in, of all places, Cromarty. And this fills me with hope that when I'm there, I'll get to watch "as merrily flit the Nimble Folk across the Northern Sky".

JIA-YI LIU/FOLIO

# Dancing lights from space | INVESTIGATING THE AURORAE

The aurorae are as beautiful as they are mysterious. **Maria-Theresia Walach** explains what we know about the creation of these ever-changing light shows



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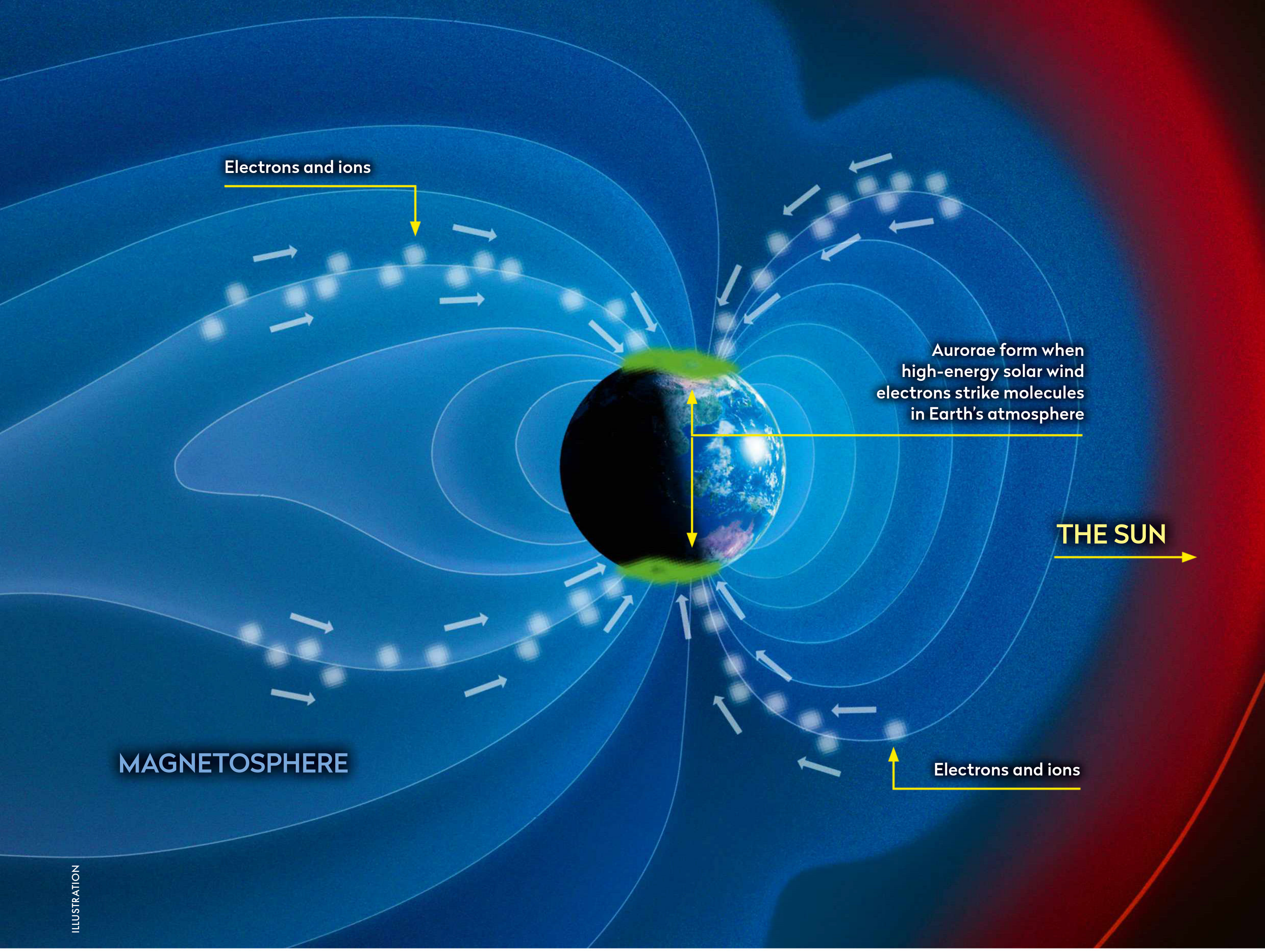
The aurora borealis over Tromsø, northern Norway, with Kvaløya Island's snowcapped mountains in the background




Dancing across the night sky, the aurorae are one of the most beautiful light shows in nature. Mysterious and elusive, they are a glorious sight, drawing people to travel to remote and frozen places in the hope of seeing them. But the lights we see waltzing overhead are only the final spectacle of a 150-million-kilometre journey of solar wind, travelling from the Sun until it crashes into our planet's magnetic field, with spectacular results.

The journey begins at the Sun, a roiling ball of plasma. Most people are familiar with the most commonly observed forms of matter – solid, liquid and gas – but plasma is the fourth. Physicist Irving Langmuir was the first to recognise plasma in 1920, when he and his colleagues were investigating charged gases and found they could not only carry electrical charges but they could also mould themselves around magnetic fields.

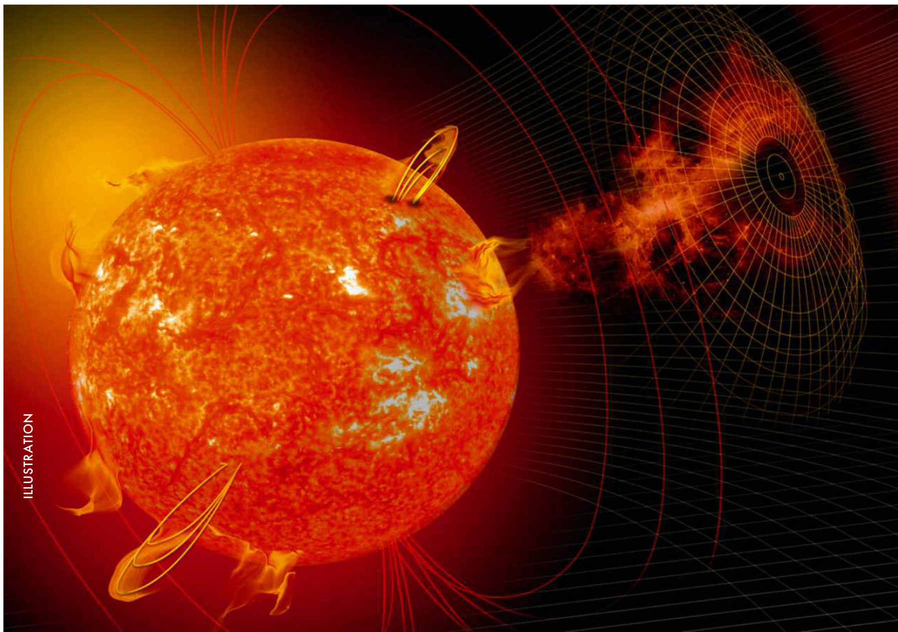
The gas had become ionised, or charged, to form what Langmuir called a plasma. Atoms get ionised when their negatively charged electrons, which surround a positive nucleus, have enough energy to escape the nucleus, so that the atom becomes charged. Sunlight can ionise the uppermost parts of our own atmosphere, but by far the biggest ball of plasma in our Solar System is the Sun. It is hot enough to have an entire atmosphere made of plasma. The gravity of the Sun is not strong enough to keep all of its plasma together, so some escapes into space, streaming outwards as the solar wind.

This solar wind whizzes through the Solar System, past all the planets – including Earth – carrying with it not just the Sun's plasma, but also its magnetic field. When the wind meets our planet, Earth's own magnetic field carves a bullet-shaped cavity into the wind, called the magnetosphere.

As Langmuir found out decades ago, magnetic fields can guide plasma movements. In the case of our magnetosphere, it guides the solar wind's plasma

**▲ Charged electrons from space speed down magnetic field lines towards Earth's polar regions**

**▼ Coronal mass ejections from the Sun, sending blasts of solar wind towards Earth, drive the process that creates aurorae**




MARK GARLICK/SCIENCE PHOTO LIBRARY, NASA, ELENA PUEYO/ISTOCK/GETTY IMAGES

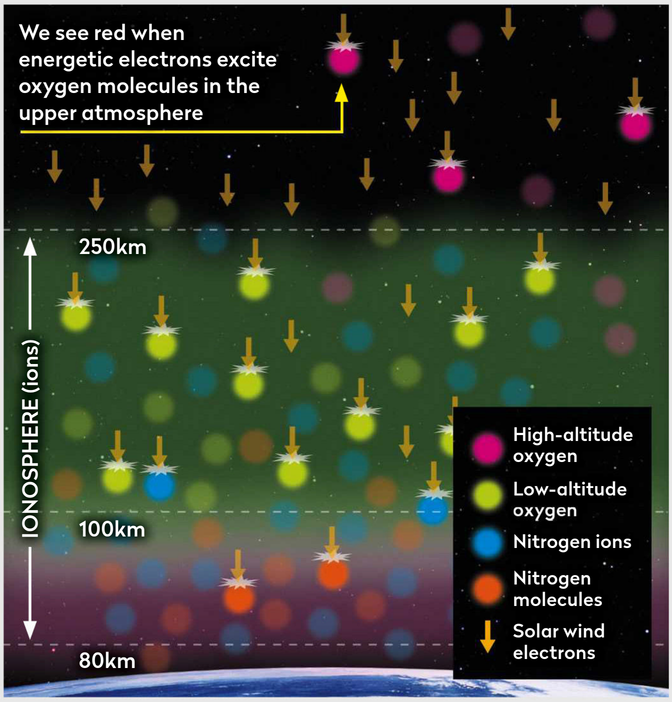
Green ripples and swirls are the most common, but aurorae can be pink, violet, blue and even blood red

## Colours of the aurora

### The colourful hues of the aurora come from our atmosphere's composition

The aurorae come in many different colours. Specific colours are created when certain molecules in the atmosphere are hit by an energetic electron, causing them to emit light with a certain frequency, which is what our eyes interpret as colour. Not all of these are visible to our eyes – the ultraviolet light of the aurorae is invisible and largely filtered out by the atmosphere, but very useful for scientists.

What is visible is, however, worth seeing. The concentrations of molecules vary with altitude, so different colours are typically given off in different parts of the atmosphere. At around 200–250km, our atmosphere's abundant oxygen gives off red light. At altitudes up to around 150km, oxygen molecule densities become much higher and they give off a green light – the most common aurorae colour you will see. Nitrogen molecules at lower altitudes can give off a blue, violet and pink light. This happens typically below 100km, where hydrogen molecules also give off a pinkish red. You might see combinations of these and – depending on the viewing angle, energy and direction of precipitating plasma – the dance of lights will be different every time.




▲ Concentrations of different molecules at the different altitudes of Earth's atmosphere spark the aurorae's kaleidoscope of colours

around our planet, protecting our atmosphere from being swept away by making it difficult for the plasma to cross its boundary. However, there is some plasma already inside the magnetosphere, mainly originating from sunlight ionising particles in Earth's atmosphere. This plasma is able to travel along magnetic field lines, which guide it into the upper part of the atmosphere, called the ionosphere.

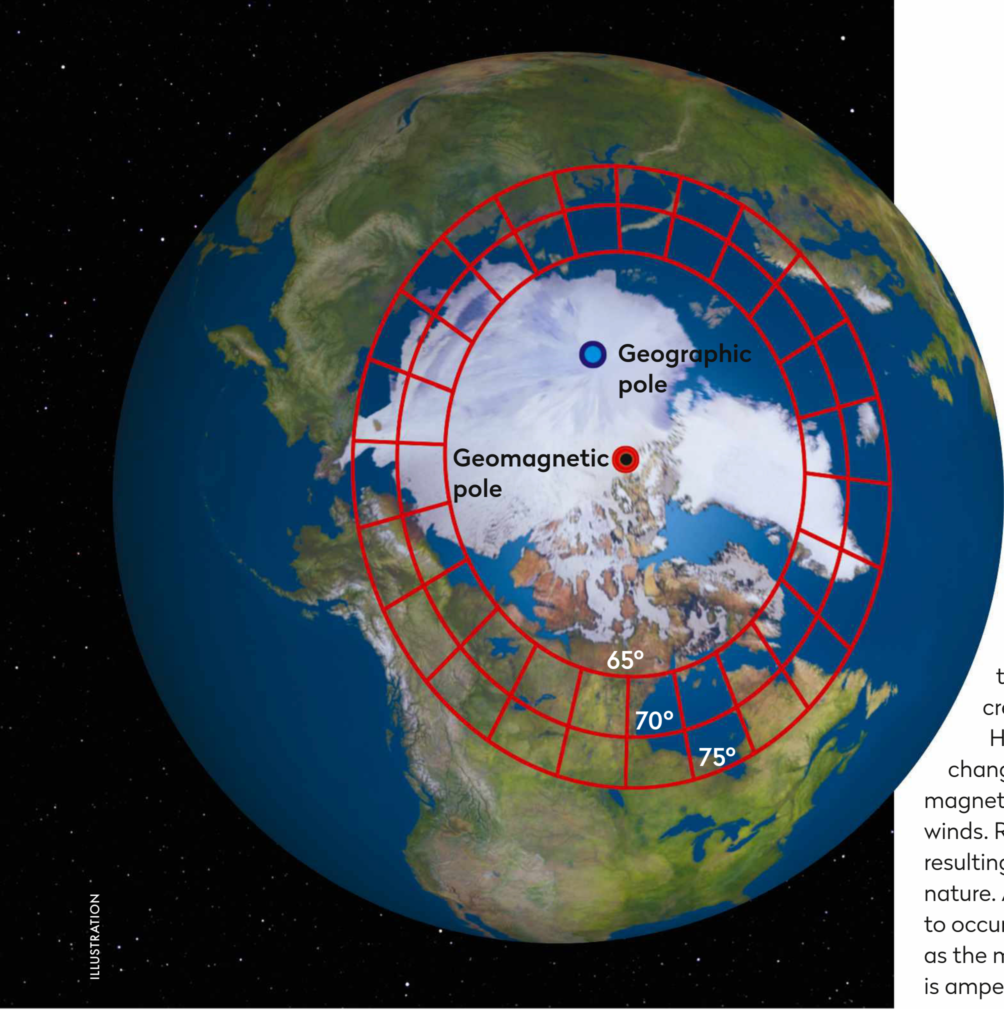
*"If the angle and speed are just right, the collision makes the atmospheric molecules vibrate, causing them to radiate light"*

### Tripping the light fantastic

It is when these currents meet the ionosphere that the magical aurorae begin to take shape. The high-energy electrons in the plasma hit molecules within the atmosphere, transferring some of their energy. If there's too little energy transferred, nothing happens. Too much and it ionises the atmospheric molecule, so it becomes plasma too. But if the angle and speed are just right, then the aurorae can shine. The collision makes the atmospheric molecules vibrate, which in turn causes them to radiate light. When enough of these molecules shine together, they create the beautiful aurorae, dancing across the sky.

The points at which the electrical currents from the magnetosphere meet the atmosphere trace out two 'auroral ovals' surrounding both the northern and southern magnetic poles. On an average day, the energy in these regions is enough to create aurorae in the ultraviolet part of the light spectrum, which is invisible to the naked eye.

Making the aurorae visible requires more energetic electrons. These can be generated through a process ▶




the Sun's. This means a portion of our magnetosphere travels with the solar wind as it sweeps around our planet, dragged towards the nightside. Here reconnection works the other way, reconnecting our magnetic field back to Earth. During this process, the plasma gets accelerated along the field lines, giving it the energy it needs to create visible aurorae.

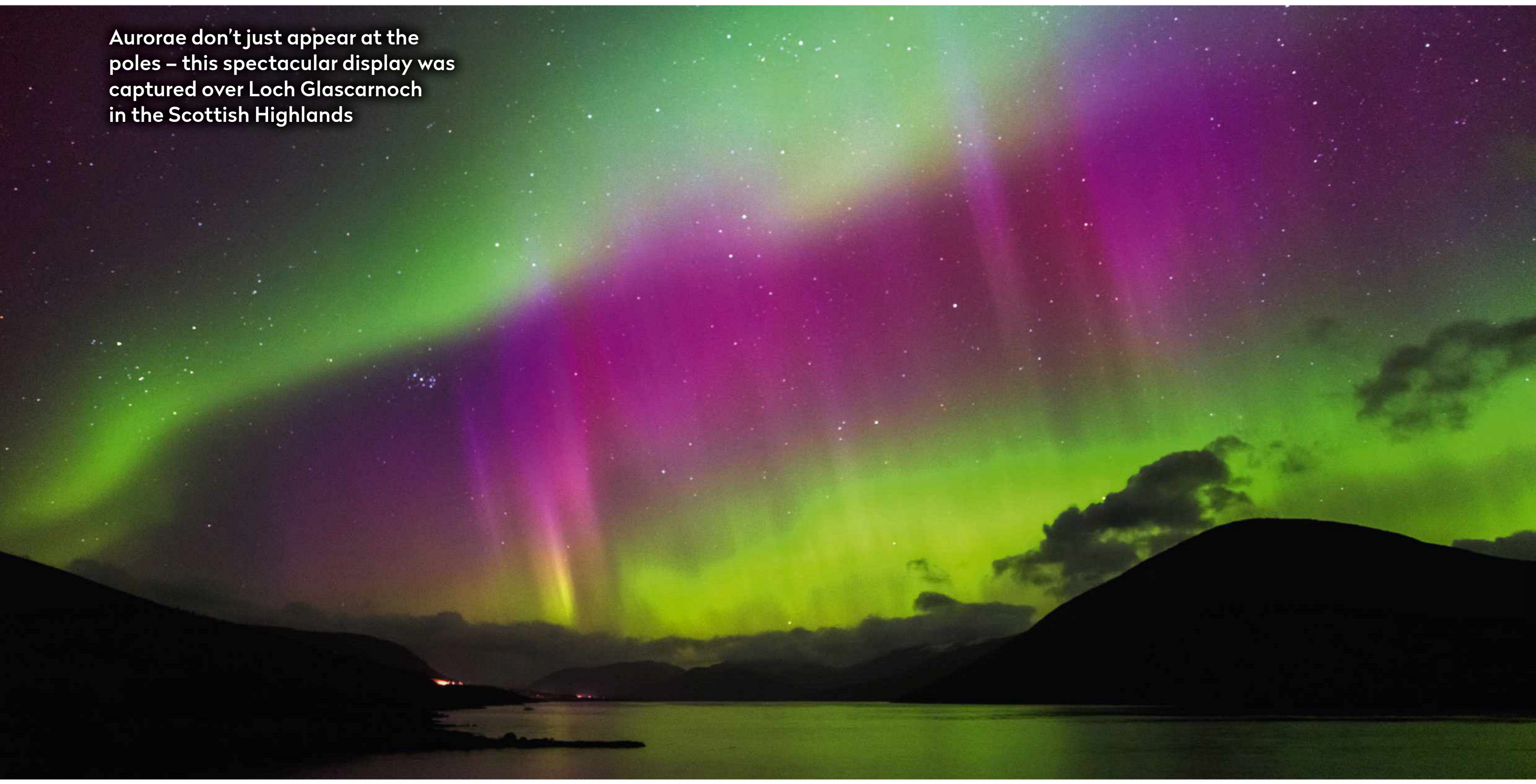
However, the magnetosphere is constantly changing, and the solar wind that buffets the magnetosphere is as unpredictable as terrestrial winds. Reconnection doesn't always happen, resulting in the aurorae's changing and elusive nature. At times when reconnection is more likely to occur, we see particularly bright and vivid aurorae as the magnetosphere's electrical current system is amped up.

▶ called reconnection, where the magnetosphere interacts with the solar wind to connect field lines that were previously separate. When reconnection occurs, it allows electric currents to carry energy and plasma across the previously impassable boundary into our magnetosphere. On the dayside of our planet, reconnection separates magnetic field lines from Earth's field and attaches them to

**▲ The auroral oval over the northern magnetic pole, where currents from the magnetosphere meet the atmosphere, triggering dazzling light shows**

## Elusive and unpredictable

There are many things that govern the probability of reconnection, such as the angle of the Sun's magnetic field as it hits Earth. The best alignment is when its magnetic field is pointing southward with respect to Earth. Due to the planet's axial tilt, this occurs more frequently around the equinoxes in September and March. Reconnection is also



**Aurorae don't just appear at the poles – this spectacular display was captured over Loch Glascarnoch in the Scottish Highlands**

# How to find the aurora

## To see the beautiful aurora, you first have to hunt them down

Mount Kirkjufell in Iceland, one of the most popular destinations for aurorae hunters – though luck and planning still play a big part

If you want to see the aurorae in person, you'll need to start by picking either the Northern or Southern Hemisphere. As there is a greater landmass underneath the northern auroral oval, however, the Arctic circle is a good place to start, particularly when travelling from the UK. The area covers Iceland, Norway, Sweden, Canada and Alaska, so there's no shortage of destinations.

The lights can make an appearance on any night, but there are certain times when they are much more likely to put on a great show. At the moment the Sun is heading towards the peak of its cycle, meaning that there is increased solar activity which raises the chances of some brilliant displays over the next few years. While the winter months have plenty to offer, the equinox months of September and March are usually the best.

Darkness is your friend because the aurorae are not always as vivid to the eye as pictures might suggest. A camera can help you draw out the details that your eyes might struggle to pick out.

Checking the weather radar for clouds could save you hours in the cold. While you are doing that, you can also check the geomagnetic conditions, or observe the solar wind. There are many apps that can help you do this and some even give you an alert, so you can enjoy a warm evening indoors until nature's light show is ready for you. And one last piece of advice: if you happen to fly near to the poles, make sure you look out of the window!

more probable if the solar wind is blowing hard, which is governed by the activity of the Sun, though the relationship is complex and high activity does not always guarantee fast speeds. An increase in sunspots can cause more complex solar wind structures to produce faster winds. Sunspots follow an 11-year cycle, starting quietly, then building to a maximum before falling back down again. The current solar cycle is ramping up in activity, with the next maximum estimated for 2025.

The best shows come from geomagnetic storms, created by activity such as coronal mass ejections. These are very unpredictable, but they do occur more frequently around the solar maximum, and throw plasma into space at incredible speeds.

## Unwrapping the enigma

The aurorae's magical appearance is matched by their mysterious nature. Even though we know where these lights come from, there are many more questions to be answered. Precise prediction, for example, remains a challenge for scientists.

To gather more data, we use not only cameras, but magnetometers to measure fluctuations in the magnetic field, as the electric currents in the atmosphere generate magnetic fields strong enough to affect Earth's global field. Radar receivers, based down here on the ground, can be used to measure the plasma moving in the ionosphere, giving us an idea of the aurorae's likely location. We can also fly spacecraft directly through aurorae, or just below them – either via an orbital satellite or by flying an experiment on a suborbital rocket – but these don't operate for long periods of time. The vastness of space means that it is unfeasible to have observations everywhere all the time, not to mention the fact that ground-based observations are far easier to operate and repair.

We have learned something about aurorae from all these observations. We know the auroral ovals can move in closer to the poles or out towards the equator depending on the balance of reconnection rates and electrical currents. What does that mean for us here on Earth? We're still working that out. The ionosphere is the lid to the neutral atmosphere we depend on, and to fully understand Earth's climate and atmosphere we need to know the relationship between the two. The problem is we have not yet fully understood how aurorae change the atmosphere underneath them and how and when the plasma moves. If we did, we might finally be able to predict that most elusive of astronomical phenomena – the aurorae.

**Maria-Theresia Walach** is a senior research associate at Lancaster University, studying the ionosphere

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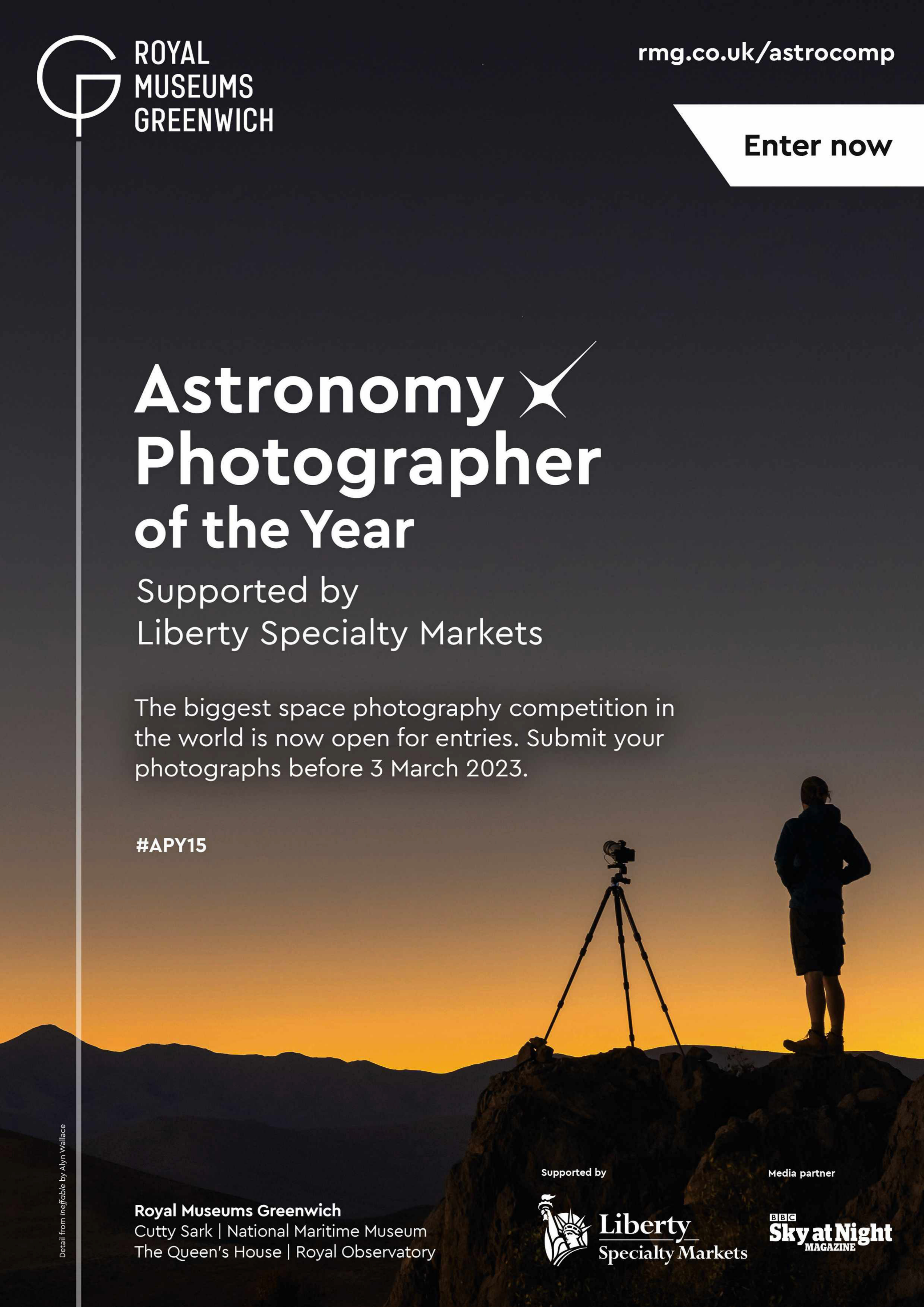
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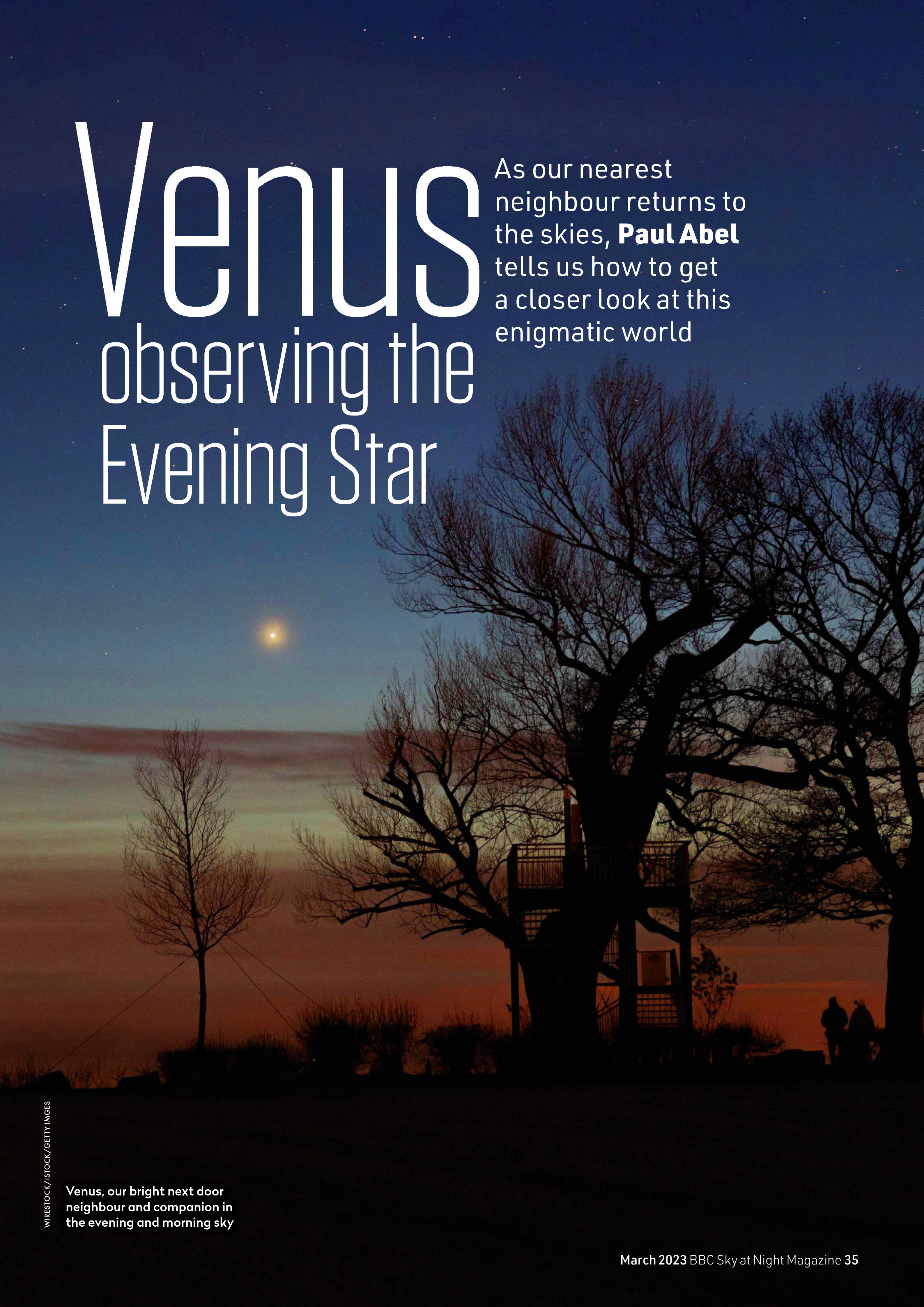

# Venus
# observing the Evening Star

As our nearest neighbour returns to the skies, **Paul Abel** tells us how to get a closer look at this enigmatic world

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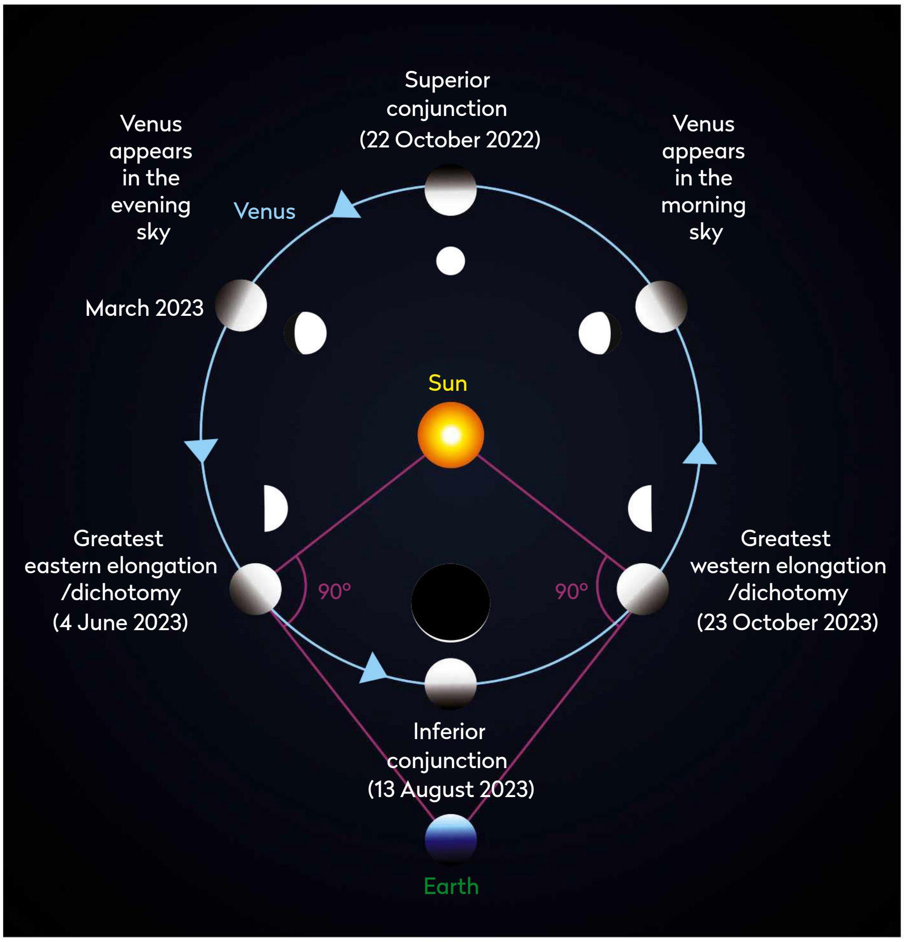
**Venus, our bright next door neighbour and companion in the evening and morning sky**

Have you noticed the bright beacon of Venus blazing away in the western sky after dark? Our nearest planetary neighbour is quite unmistakable, sparkling as she does with a brilliant silvery light. It's no wonder the planet represents beauty and mystery in Greek mythology. Though a number of spacecraft have visited Venus, she is reluctant to reveal her secrets and hides her volcano-covered surface beneath a thick atmosphere. But, despite this, there are many mysteries an amateur observer from Earth can help uncover.

Sometimes unfairly regarded as 'bland', Venus is actually an excellent telescopic target for Northern Hemisphere observers during the spring months. Whether visually or through imaging, your observations of Venus could play an important part in monitoring the planet – for example, by helping to discover if there are still active volcanoes lighting up the surface. Here I'll tell you how to take a closer look at this mysterious world.

# Orbits and elongations

## Like the Moon, Venus appears to go through phases as it moves across the night sky




▲ **Venus passes through elongations (west and east) at its greatest separation from the Sun, and inferior and superior conjunctions at its closest and furthest, respectively, from Earth**

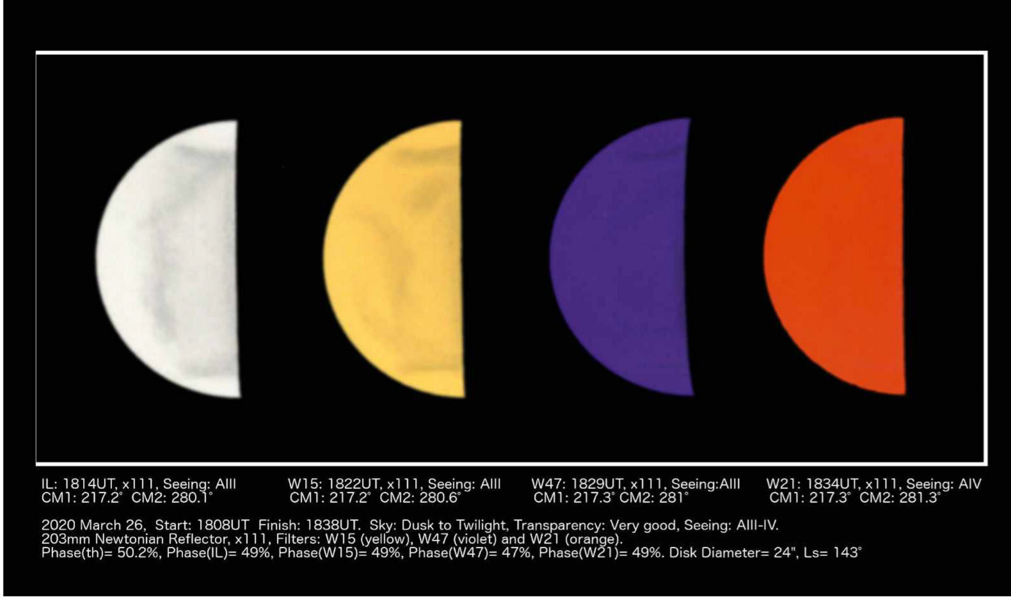
The motion of the inner planets in the sky is quite different from that of the outer planets. Instead of oppositions, Mercury and Venus pass through elongations. Those on the western side of the Sun are visible in the morning sky (western elongation) and those on the eastern side, in the evening sky (eastern elongation).

The graphic above shows the changes we see as Venus completes an orbit: starting at superior conjunction, when the Sun effectively lies between Venus and Earth, though the planet is too close to the Sun in the sky to observe at this point. This last occurred on 22 October 2022, and the planet is now on the Sun's eastern side and visible in the evening sky.

A phenomenon unique to Mercury and Venus is that we can observe them passing through the same phases as the Moon, from full to new. Telescopically, Venus appears as a small gibbous disc after conjunction. The phase will decrease over time and the apparent diameter will increase as Venus moves closer to Earth. Venus reaches 50% illumination (dichotomy) when it is usually furthest from the Sun in the sky – a point called greatest eastern elongation, which happens on 4 June. The planet continues to move closer to Earth, becoming an increasingly slim crescent until it reaches inferior conjunction where it lies between the Sun and Earth. This occurs on 13 August this year. After this date, the planet transitions from an evening object and moves into the morning sky, starting a new western elongation and the whole cycle occurs in reverse.

Not all elongations are equally favourable, as the cycle happens at different times. In general, the planet is highest and best-placed when it's in the evening sky in the winter and spring months, and in the summer when it's in the morning sky. Every eight years, Venus returns to the same point in the sky, and this is called the synodic period.

SEBASTIAN SONNEN/ISTOCK/GETTY IMAGES, PAUL ABEL, KONSTANTIN VON_POSCHINGER/CCDGUIDE.COM




▲ **A log of your observing sessions – recording the date, time, seeing conditions, telescope, filters and magnification used – will help you quickly build up your Venus knowledge**

# Watching Venus

## Filters and a logbook will help you track the planet's changing face

People often find their first telescopic view of Venus disappointing, as they tend to observe it when the sky is darker and the planet is very brilliant. At such times, Venus is low down. The glare from the disc and poor seeing mean all you are likely to see is something resembling a steam pudding! The best time to view Venus is during dusk, when the sky is still bright and the planet is higher in the sky.

You will need at least a 3-inch telescope and a magnification of about x120 to see any details beyond the phase. Give your eyes a chance to get used to looking at Venus, then see if you can make out the bright areas covering the north and south poles, called cusp caps. They are often bordered by darker grey cusp collars and all of these are likely to change from night to night during the elongation.

Sometimes the cloud markings present a distinctive Y-shaped feature and bright spots may also appear, often close to the limb – although bear in mind that seeing cloud markings on Venus is easier for people whose eyesight is more sensitive to blue light.

Another phenomenon associated with Venus is the Schröter effect, when the observed phases of the planet are different from the predicted phases (see below). This will be obvious in small telescopes. You will also find using optical filters a great help when observing Venus. Most telescopes come with a set. They are easy to use and usually screw into the barrel of the eyepiece. On the side of each filter you'll find printed its Wratten number and this uniquely identifies it. For example, a yellow W12 or W15 filter will help sharpen Venus's features and reduce the glare, while a blue filter like a W38A or W47 can help to bring out cloud markings. You'll find cloud markings and features change appearance in different filters, as they reveal different levels of the atmosphere.

You will get more out of your observing sessions if you write down what you have seen. I now have several Venus logbooks going back decades, where I record the combination of eyepieces and filters that worked best, and from the drawings I can see which phenomena repeat themselves. A record like this means you are not returning to the eyepiece new each time. Instead you're actively building on your experiences. I find it invaluable.

Making a drawing is the best way to record your observations. I always use a 50mm blank and start by drawing in the phase, then putting in any cloud markings and the cusp caps and collars. Make sure that you record the date, time (in UT), the telescope you used and magnification. If you have made a drawing using a filter, make sure to record its number and details. Over the course of an elongation, you will see your drawings improve and the amount of fine detail you can see will increase. ▶

# The Schröter effect

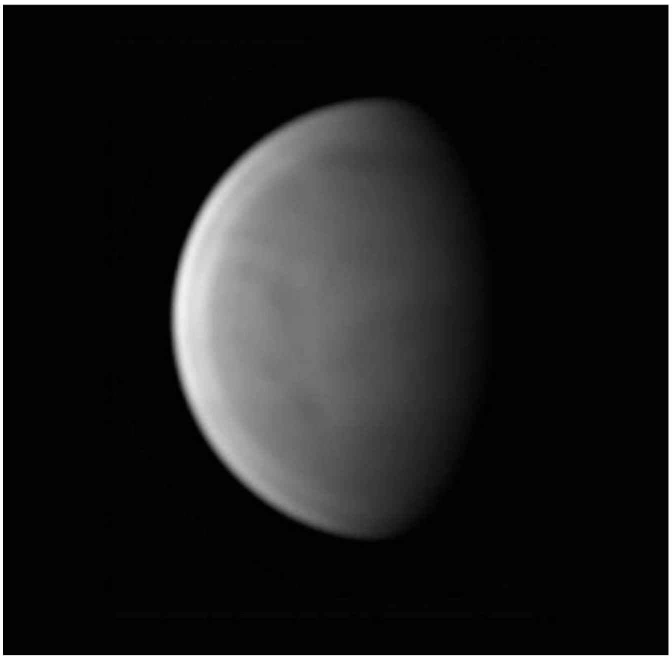
## Venus's phases are odd – what we actually see is out of step with the predicted timings

The *observed* phase of Venus is always slightly less than the *predicted* phase of Venus, an effect first recorded by Johannes Schröter in 1793. This phase anomaly (as it's also called) is best shown when Venus appears to be at 50% illumination (dichotomy) in a telescope. This always occurs earlier than the predicted date for evening elongations and later for morning ones. The reason the phase anomaly occurs is still debated, but it is likely to do with Venus's thick atmosphere scattering light, and is even more pronounced in a blue filter.

The next dichotomy is predicted to occur on 4 June, so start looking carefully at the phase of Venus a week before this. Early dusk is best as the planet will be higher in the sky. The effect can be seen in telescopes of 3-inch aperture, and a yellow filter will help make the terminator easier to see. When the terminator is a completely straight line, Venus is at 50% illumination – this is called observed dichotomy and it will likely occur three or four days before 4 June.

▶ **Be prepared to catch Venus half-lit – it will be earlier than expected**

Make sure you record the date in your logbook, and remember: the date of observed dichotomy varies, so start in plenty of time!



▲ Clyde Foster in South Africa used infrared filters to capture the wave discontinuity phenomenon in the atmosphere in May 2022

▲ This infrared image by amateur astronomers Anthony Wesley and Phil Miles shows bright surface spots on Venus's night side

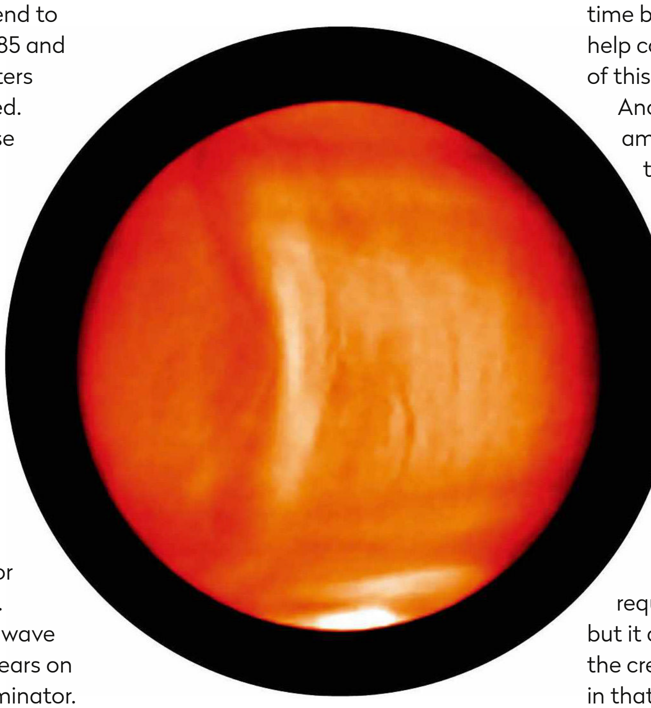
# Venus in infrared

## Several scientifically intriguing features become visible at longer wavelengths

In the last decade, many amateur astronomers have started using filters to image Venus in wavelengths well beyond the visible part of the spectrum. To capture Venus in infrared you will need a filter and a camera to record the images. You will find that infrared filters tend to transmit wavelengths between 685 and 850nm (nanometres); I've seen filters centred on 790nm commonly used.

In December 2015, the Japanese Akatsuki spacecraft recorded a strange infrared feature – a vast 10,000km bow-shaped wave of clouds extending from north to south over Venus's equator. In the years since, a number of amateur astronomers have not only also captured the feature but have tracked it. Interestingly, the wave phenomenon is not always present – in some elongations it has been completely absent. It did return in 2022 and persisted for many months longer than before.

This phenomenon is called the wave discontinuity of Venus and it appears on the day side, usually near the terminator. One explanation for it is that it is caused by the upwelling of air over mountainous terrain. Several scientists have speculated that the discontinuity may be caused by active volcanoes. If you have an infrared filter and camera, try imaging Venus as often as possible, and if you manage to record it, send your images to me at the Mercury and Venus Section of the British Astronomical Association (**britastro.org**), of which I'm the director. We compile amateur observations together to detect and monitor changes to the planet. The best time to try this is when Venus is in the gibbous stage, so have a go at any time before dichotomy on 4 June and help contribute to our understanding of this planet.

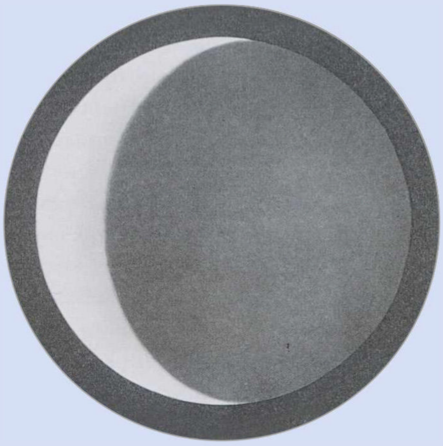


▲ The curious wave discontinuity, a colossal cloud seen stretching from pole to pole by the Akatsuki spacecraft in 2015

Another new avenue of exploration for amateurs is in using infrared to image the night side of Venus. In April and May of 2017, Australian amateurs Anthony Wesley and Phil Miles's night-side images recorded a number of bright spots on the surface, which have since disappeared. Many scientists believe that Venus could still be volcanically active, so one explanation could be that these were active volcanoes. Imaging them on the night side would be a way of proving this.

Imaging the night side also requires an infrared filter and camera, but it can only be done when Venus is in the crescent stage. The difficulty comes in that the sunlit crescent can saturate the image, but this stage will be visible in late June, so that would be a good time to try, if you want a challenge.

CLYDE FORSTER, PHIL MILES/ANTHONY WESLEY, ISAS/JAXA, SIR PATRICK MOORE HERITAGE TRUST/COURTESY OF THE EXECUTORS, SEBASTIAN VOLTMER/CCDGUIDE.COM



▲ Patrick Moore drew the ashen light based on an observation he made with his 15-inch reflector on 27 May 1980

# The ashen light

## No one knows for sure why some report seeing a ghostly glow lighting up the planet's dark side

The ashen light refers to the pale glow seen on the night side of Venus by visual observers, and is said to look similar to earthshine on the Moon. The phenomenon is somewhat controversial as it has never been imaged. However, a number of reliable observers, including Patrick Moore, have seen it repeatedly on a number of occasions.

Recent observations made by NASA's Parker Solar Probe might add validity to the observations. In July 2020 and February 2022, Parker saw surface details on the night side of Venus in infrared wavelengths that could also be seen visually. Venus's surface glows in the infrared and if the clouds over the night side are thin for some reason, then sightings of the hot, faintly glowing surface might be the cause of the light, particularly for those visually biased towards red light.

# Ultraviolet cloud-watching

## Track the speedy Venusian atmosphere by imaging the motion of cloud formations

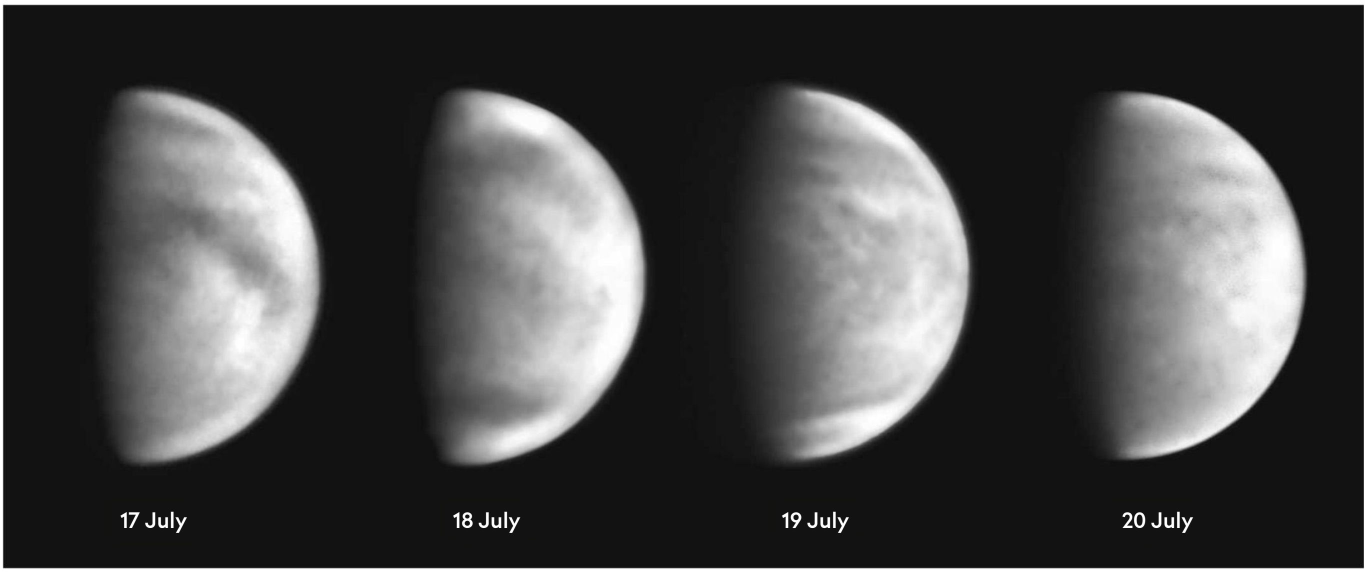
As with infrared imaging, ultraviolet images have become essential in monitoring long-term changes on the planet and are another useful tool for amateur and professional astronomers studying the Venusian atmosphere.

To make observations of Venus in the ultraviolet, you will need a filter that only allows ultraviolet wavelengths of light to pass through. Typically these are wavelengths between 320 and 380nm. There are a number of such filters available, but since this part of the spectrum cannot be seen directly, you will need to use a camera to record an image. Be sure to double-check that your camera can detect ultraviolet light, as some aren't sensitive to these wavelengths.

The cloud markings of Venus are best seen in ultraviolet, and these images often reveal quite complex patterns and can be very informative. If multiple images are taken showing a formation moving along the disc, estimates can be made of the wind speed in the upper atmosphere. We know that the atmosphere of Venus undergoes 'super-rotation', circling the planet once every four to five days, whereas the surface takes a more leisurely 243 days to complete a single revolution.

Although photographing Venus in ultraviolet takes some practice and requires good seeing conditions, it can deliver excellent results.

**Paul Abel** is an astrophysicist and the director of the British Astronomical Association's Mercury and Venus section




▲ Venus's fast-moving cloud formations, recorded through Schuler and Baader ultraviolet filters in 2018

Cosmology Crash Course

# How is the Universe so big?

Your questions answered as **Govert Schilling** continues to explain cosmology's most confusing concepts

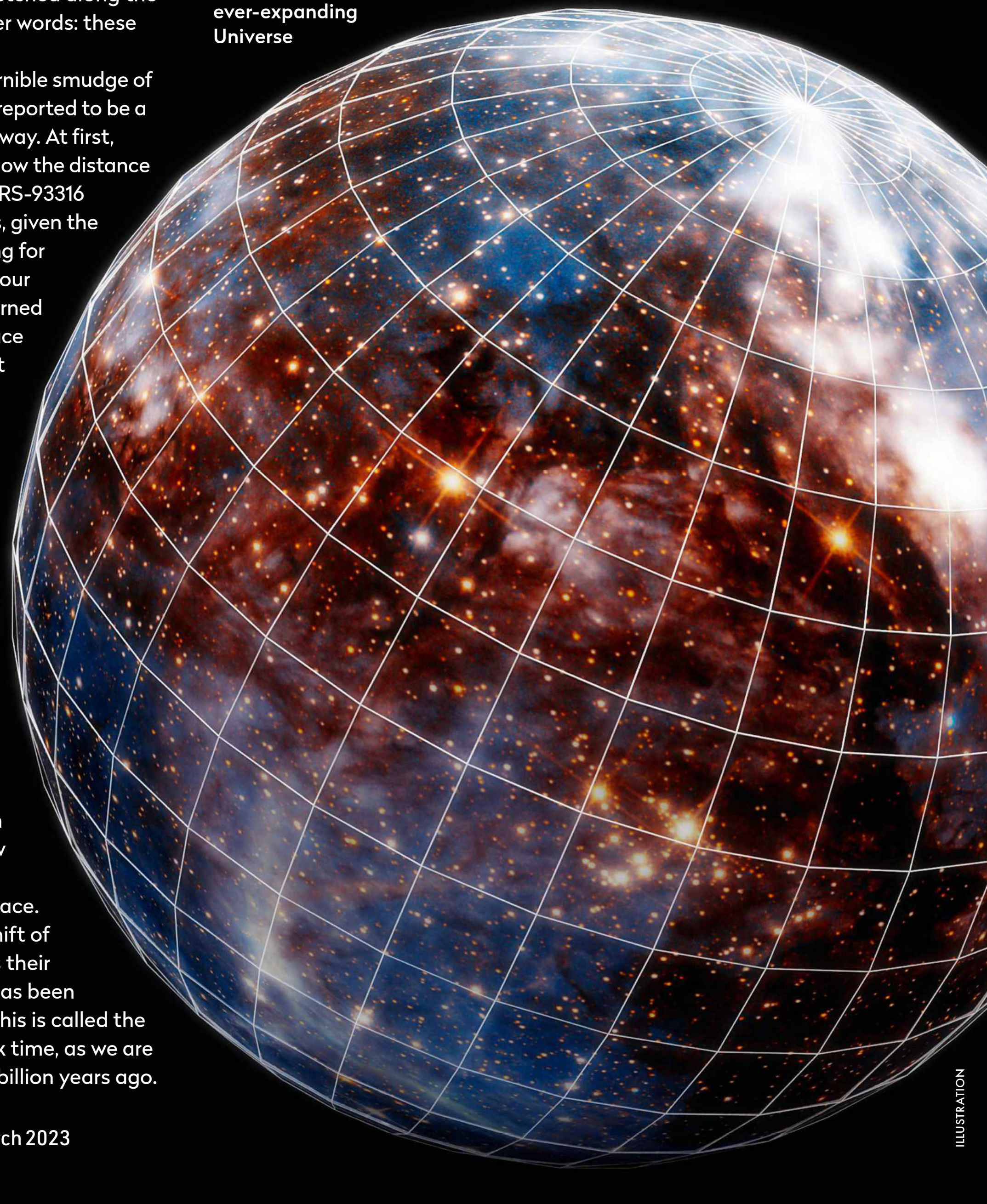
Weeks after NASA released the very first images from the James Webb Space Telescope (JWST), astronomers began reporting the discovery of extremely redshifted galaxies. As we saw in the first instalment of this series, a high redshift means the light has been travelling through the expanding Universe, getting stretched along the way, for a very long time. In other words: these galaxies are incredibly far away.

One galaxy, an almost indiscernible smudge of light labelled CEERS-93316, was reported to be a staggering 35 billion lightyears away. At first, it may seem difficult to explain how the distance between our Milky Way and CEERS-93316 has grown to 35 billion lightyears, given the Universe has only been expanding for 13.8 billion years. But in Part 2 of our Cosmology Crash Course, we learned that the expansion of empty space is not constrained at all by Albert Einstein's fundamental velocity-of-light speed limit. However, when it comes to objects in an ever-expanding Universe, the concept of distance becomes a bit murky, so this month we'll take a closer look at what we really mean by 'distance'.

## Distant relative

First, it's important to realise that we cannot measure cosmic distances directly (at least not outside our Solar System). For galaxies, redshift is the only proxy we have, and in truth it only actually tells us how long the galaxy's light has been travelling through expanding space. For instance, a galaxy at a redshift of 5 (its wavelengths are five times their original value) means the light has been travelling for 12.6 billion years. This is called the light travel time, or the lookback time, as we are seeing the galaxy as it was 12.6 billion years ago.

Intuitively, you would assume that this particular galaxy is 12.6 billion lightyears away. But in reality the galaxy is much further away. After emitting the light that we receive today, the expansion of space pushed the remote galaxy and our own ever further apart. It turns out that the 'true' distance of our redshift-5 galaxy (often called the comoving distance) is currently almost 26 billion lightyears.



▼ Size and distance are slippery concepts in an ever-expanding Universe

ILLUSTRATION

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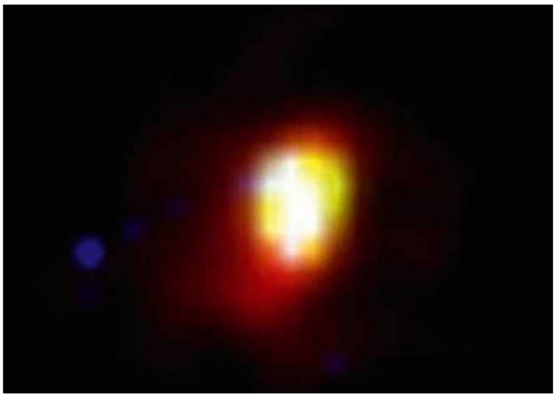
A photograph today of the Andromeda Galaxy shows it as it was 2.5 million years ago, long before modern humans walked the Earth

# Telescopes as time machines

### Distant galaxies give us windows into the past

Because of the finite speed of light, we see distant objects as they were when the light was emitted long ago, not as they are now. To many people, this may seem to be a nuisance – astronomers will never be able to learn what remote galaxies look like *right now*. However, to cosmologists it's a wonderful gift of nature. Thanks to the lookback time, they are able to study the early youth of the Universe. All you need to do is to look very far away into space and you're automatically looking far back in time. Thus, the full 13.8-billion-year history of the Universe becomes accessible to scientific inquiry.



▲ **CEERS-93316, 35 billion lightyears away – a glimpse of the Universe just 235 million years after the Big Bang**

The exact value depends partly on how the Universe has been expanding through time, which we don't know in detail – but in any case, a remote galaxy is always further away than its light travel time would suggest.

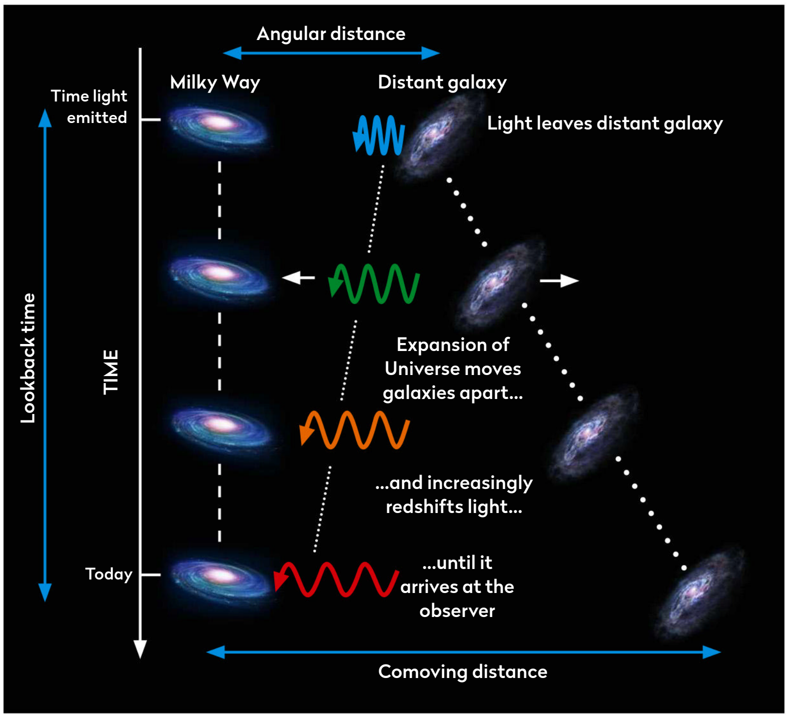
## Size matters

Surprisingly, despite being 26 billion lightyears distant, the galaxy still appears as a slightly extended object on the sky, with a particular (albeit small) angular size. That's because its perceived angular size was set at the time the galaxy's light was emitted, 12.6 billion years ago. Back then, it was much closer to our Milky Way. For a redshift of 5, it emitted the light when it was 4.3 billion lightyears from our Galaxy – this is its angular size distance. Because the expansion of space constantly moved the goalposts back, it nevertheless took 12.6 billion years for the light to reach us.

As if this isn't confusing enough, there's also a luminosity distance, which tells you how faint the galaxy appears. Because of the expansion of space, which decreases both the energy and the arrival rate of photons, our remote galaxy looks much fainter than you would expect for its actual (comoving) distance of 26 billion lightyears. In a non-expanding Universe, it would only be this faint if it were located at a distance of a whopping 155 billion lightyears!

Returning to the recently discovered galaxy CEERS-93316: the light has been travelling from this galaxy for 13.5 billion years. If you could lay down a ruler today, you'd measure its comoving distance to be around 35 billion lightyears. Because the Universe was much smaller when the galaxy emitted its light, its angular size distance is two billion lightyears. Finally, the expansion of the Universe decreasing its brightness means its luminosity distance is 615 billion lightyears, giving it an incredibly low surface brightness. It should be obvious now why it hadn't been observed until JWST came along, and its discovery is an impressive tribute to the telescope's light-gathering power!

▼ **The Universe isn't static – light from remote galaxies looks to us as it did before expansion pushed them away**




**Govert Schilling**'s book *The Elephant in the Universe* is published by Harvard University Press

BBC Sky at Night MAGAZINE

16-PAGE CENTRE PULLOUT

# The Sky Guide

MARCH 2023

## VENUS MEETS JUPITER

Catch the spectacular close encounter of two bright planets on 1 March

## CERES DROPS BY

The dwarf planet is on view near the Virgo Cluster all month

## BINOCULAR TOUR

Delightful sights to find in Canes Venatici

PETE LAWRENCE

### About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

**Steve Tonkin** is a binocular observer. Find his tour of the best sights for both eyes on page 54

### Also on view this month…

- ✦ Mars crosses paths with star cluster M35
- ✦ Can you spot the eerie Zodiacal Light?
- ✦ Six deep-sky gems to discover in Gemini

### Red light friendly

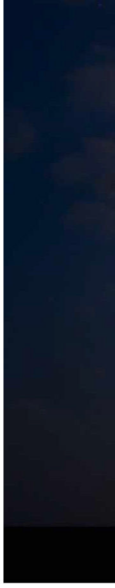
To preserve your night vision, this Sky Guide can be read using a red light under dark skies

### Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

# MARCH HIGHLIGHTS

Your guide to the night sky this month



**Wednesday 1**

This evening and tomorrow evening, Jupiter and Venus appear really close to one another in the evening twilight after sunset. This evening they are 0.6° apart and tomorrow they will appear 0.8° apart.

**Thursday 2**

Mercury and Saturn are 1° apart as they rise this morning. Not well positioned, it may be possible to see them in a blue sky after sunrise. Their closest separation of 52 arcminutes occurs at 14:40 UT.

**Saturday 4**

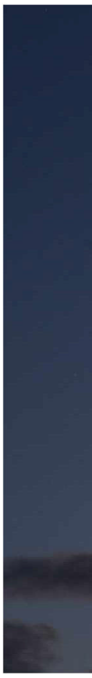
The Moon's southern polar region is favourably tipped into view, thanks to lunar libration.

**Tuesday ▶ 14**

As the 60%-lit waning gibbous Moon rises this morning around 02:00 UT, it'll be just over a degree east-northeast of mag. +1.0 Antares (Alpha (α) Scorpii).

**◀ Saturday 18**

If you have light-pollution-free skies, this is a good time to look out for the gentle and very subtle cone of light sometimes seen over towards the west 90 or so minutes after sunset, known as the Zodiacal Light.



**Wednesday ▶ 22**

This evening an extremely slender 1%-lit waxing crescent Moon sits 1.8° southwest of mag. –1.9 Jupiter. Catch this tricky but rewarding sight low above the western horizon around 19:00 UT.

**Saturday 25**

As the 20%-lit waxing crescent Moon approaches the west-northwest horizon, it'll be located close to the Pleiades open cluster – a good opportunity for a stunning photo.

**Sunday 26**

Ceres will pass across mag. +9.3 galaxy M100 tonight and into tomorrow morning.

British Summer Time begins in the UK. The clocks go forward one hour at 01:00 UT this morning to become 02:00 BST.

**Monday 27**

In the evening twilight after sunset, mag. –1.3 Mercury and mag. –1.9 Jupiter are just 1.5° apart, low above the western horizon.

**◀ Wednesday 29**

Mag. +1.0 Mars sits 1.2° north of fifth-magnitude open cluster M35 this evening.

PETE LAWRENCE X 7

## Wednesday 15

Lunar libration reveals views of the Moon's northwest region today.

## Monday ▶ 20

The centre of the Sun crosses the celestial equator at precisely 21:25 UT today, defining the March equinox. In the Northern Hemisphere it's known as the vernal or spring equinox.

## Tuesday 21

Dwarf planet Ceres reaches opposition, shining at mag. +6.6 in the constellation of Coma Berenices, just north of the Virgo galaxy cluster.

## Thursday 23

Over the course of the next few evenings there's a good opportunity to catch features on the Moon's east limb, rotated into view by favourable libration.

## Friday 24

The 9%-lit waxing crescent Moon is 0.9° south of Venus at 10:10 UT. Later, after sunset, the pair form a stunning sight low in the west.

As it sets, the Moon is 2° from Uranus.

## Tuesday ▶ 28

The 39%-lit waxing crescent Moon sits 6.6° from mag. +0.9 Mars this morning as the pair are close to setting at the northwest horizon just before 03:00 BST (02:00 UT).

## Thursday 30

Mag. –3.9 Venus sits 1.2° north of mag. +5.8 Uranus this evening. Catch the pair above the western horizon after the Sun sets.

## Family stargazing

The Beehive Cluster, M44, is a superb and easy target for youngsters to hunt down. Start at the Plough, on the side nearest the handle. Extend a line down towards the horizon for a distance twice the length of the Plough to find the bright star Regulus. Next, find Orion. Extend a line from Orion's lower-right star (Rigel) through its upper-right star (Betelgeuse) for twice that distance again to find Castor (upper) and Pollux (lower). Using binoculars, you'll find M44 slightly below the mid-point of the line joining Castor to Regulus.
**www.bbc.co.uk/cbeebies/shows/stargazing**

# NEED TO KNOW

The terms and symbols used in The Sky Guide

**Universal Time (UT) and British Summer Time (BST)**
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

**RA (Right ascension) and dec. (declination)**
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

**Family friendly**
Objects marked with this icon are perfect for showing to children

**Naked eye**
Allow 20 minutes for your eyes to become dark-adapted

**Photo opp**
Use a CCD, planetary camera or standard DSLR

**Binoculars**
10x50 recommended

**Small/ medium scope**
Reflector/SCT under 6 inches, refractor under 4 inches

**Large scope**
Reflector/SCT over 6 inches, refractor over 4 inches


## GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/10_easylessons** for our 10-step guide to getting started and **bit.ly/buy_scope** for advice on choosing a scope

DON'T MISS

# Planetary conjunctions

**BEST TIME TO SEE:** Various times throughout the month

March plays host to a number of interesting conjunctions, starting off in spectacular fashion with a very close evening encounter between Venus and Jupiter. For the UK, the closest evening approach occurs on 1 March when the planets appear separated by just 36 arcminutes before setting.

The best view is around 19:25 UT when they are about 11° up and 38 arcminutes apart under dark sky conditions. Jupiter will be bright at mag. –1.9, but will be completely outshone by mag. –3.9 Venus.

Through a telescope, both can be seen in the same field, in a low-power eyepiece. As 38 arcminutes is about one-and-a-third times the apparent diameter of the Moon, if you have an eyepiece that shows the Moon with plenty of space around it, this should show both planets clearly.

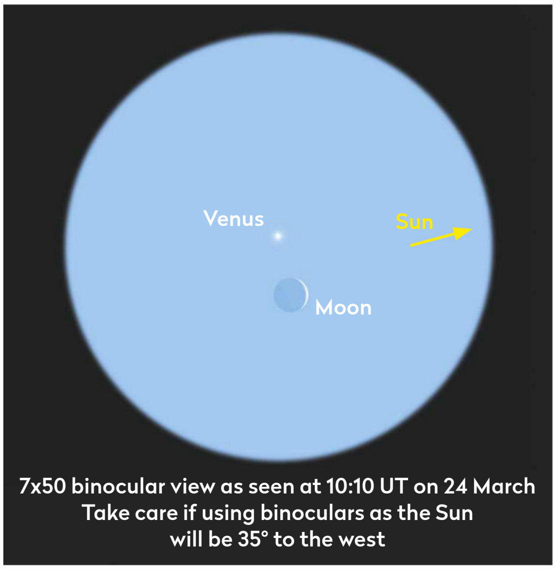
Venus is emerging into the evening sky after inferior conjunction on 22 October 2022. Consequently it is on the far side of its orbit and appears relatively small at 12 arcseconds with a gibbous phase of 85%. Jupiter will look almost three times larger at 34 arcseconds. On the evening of 1 March, all four Galilean moons are on display too, lining the event up for a great astrophoto.

Venus edges further east on the evening of 2 March, remaining close to Jupiter. At 18:15 UT, just after sunset from the centre of the UK, the pair are 45 arcminutes apart. The sky will still be light but these bright planets fare well.

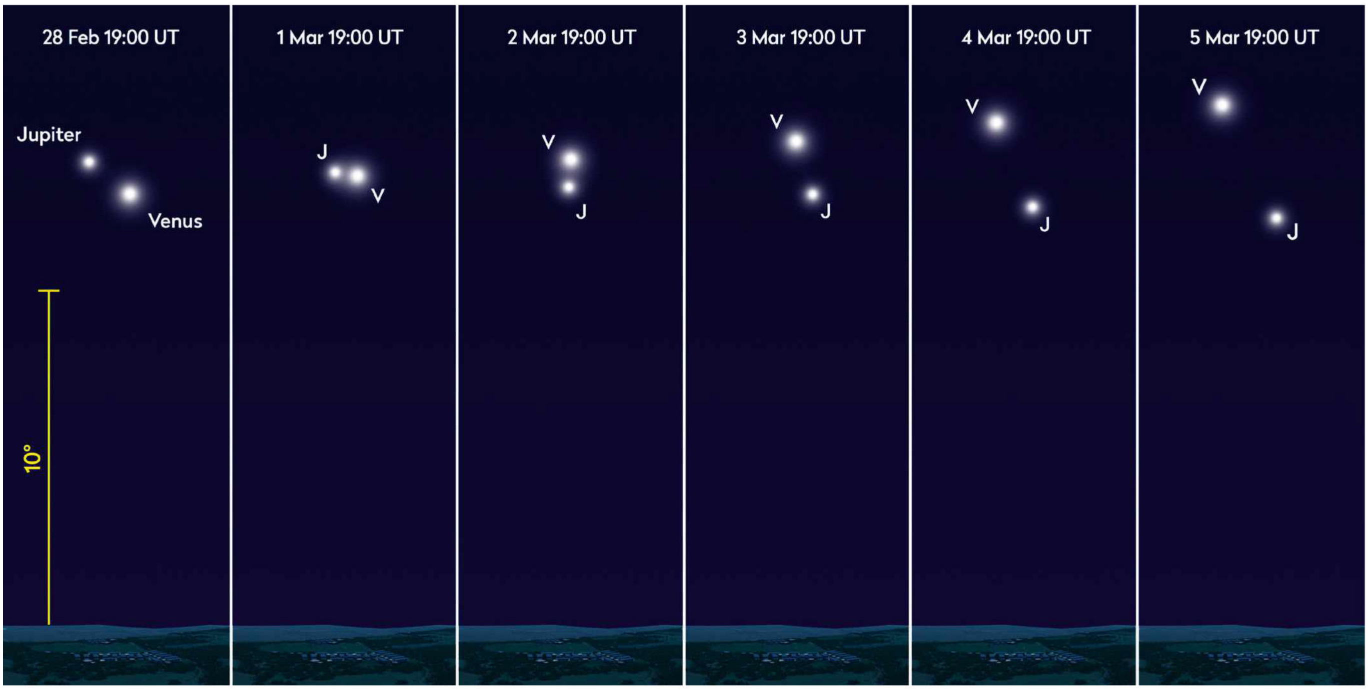
If you can locate Venus shortly after the pair rise on 2 March, say around 09:00 UT, you'll be able to catch them in a daylight sky at their narrowest separation of 30 arcminutes. Then at 10:00 UT during the morning of 24 March, Venus appears 57 arcminutes north of a slender 9%-lit waxing crescent Moon, 24° above the eastern horizon.

Venus's eastward march has it pass just north of Uranus on 30 and 31 March. On the evening of 30 March, mag. +5.8 Uranus appears 1.2° south (below left from the UK) of Venus at 21:40 BST (20:40 UT). The following evening the distance increases to 1.7°, Uranus appearing south and slightly west (below and slightly left, from the UK) of Venus on this date.

Finally, on 26–29 March mag. –1.9 Jupiter and mag. –1.3 Mercury have a series of close evening encounters, coming closest on 27 and 28 March (1.5° then 1.6° apart), low above the western horizon 30 minutes or so after sunset.




▲ Venus and a slender 9%-lit Moon put on a daytime display above the eastern horizon on 24 March




▲ Jupiter and Venus start the month with a series of close evening encounters, Venus shining 6.3 times brighter than already-bright Jupiter

ALL PICTURES: PETE LAWRENCE


Mars will pass to the north of the open cluster M35 towards the end of March

# Mars passes M35

**BEST TIME TO SEE:** 27–31 March, 21:40 BST (20:40 UT)

As Mars recedes from Earth, its telescopic appearance wanes. At the start of March, the Red Planet shines at mag. +0.4, presenting an apparent disc measuring 8 arcseconds across. However, by the end of March Mars will dim to mag. +1.0 and shrink to just 6 arcseconds across.

Although this makes it harder to observe and image, through binoculars or a widefield telescope there are still things to look out for. At the start of March, Mars is in Taurus, between the Bull's horns, moving prograde, or east, against the background stars. Its travels take it from Taurus and into Gemini towards the end of the month, ahead of an encounter with the beautiful binocular open cluster, M35, around 2,970 lightyears away.

From the UK, Mars maintains a decent altitude under dark skies all month, ideal conditions for viewing the encounter. The action starts on 27 March, when mag. +0.9 Mars is joined by a 37%-lit waxing crescent Moon to the south of the star Elnath (Beta (β) Tauri) at 21:40 BST (20:40 UT). At this time, Mars will be 8.2° east of the Moon and 1.7° northwest of M35. Just before they all set, the Moon–Mars distance will have decreased to 6.1°, Mars also getting a tiny bit closer to the cluster, the distance now being 1.6°.

On the evening of 28 March at 21:40 BST (20:40 UT), the Moon's phase will be 47%-illuminated or virtually first quarter, its disc now located 3.8° northeast of Mars. The planet will also be nearer the star cluster, the centre-to-centre separation of the two being 1.4°. On the evening of 29 March, the now waxing gibbous Moon leaves the scene, being closer to the twin stars, Castor (Alpha (α) Geminorum) and Pollux (Beta (β) Geminorum). Mars will appear 1.2° north of M35, a separation repeated on the night of 30 March. On 31 March, the planet slowly separates from the cluster, now appearing 1.4° from M35's centre.

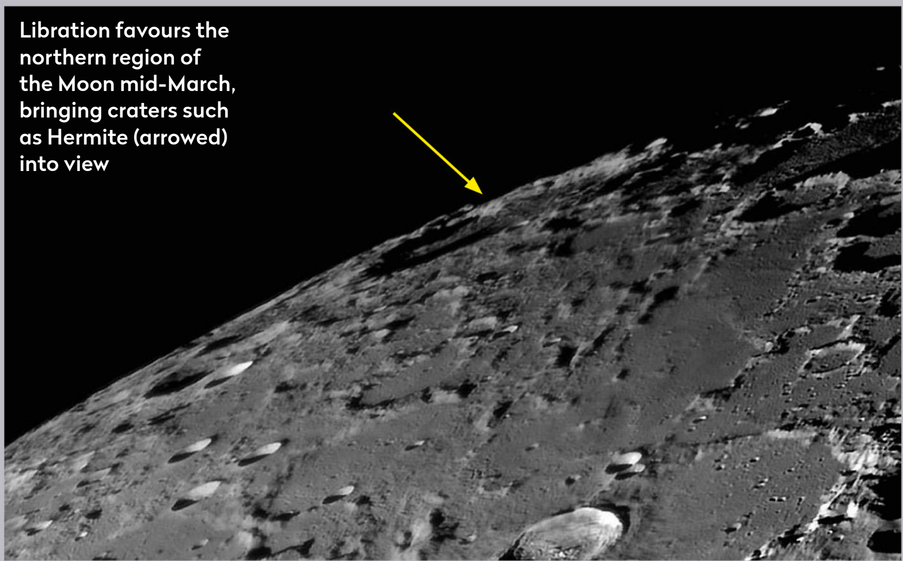
# Favourable northern lunar libration

**BEST TIME TO SEE:** Morning sky, 13–18 March

From Earth, the Moon appears to wobble. Known as libration, this effect is caused by the Moon's elliptical and tilted orbit. It allows us to see more of the Moon's tidally-locked globe than you'd expect, revealing 59 per cent of the lunar surface over time. When one edge of the Moon tilts favourably towards Earth, extra features roll into view. However, to see them at their best, the phase has to be optimal too.

In mid-March, the waning Moon presents good libration prospects for observing the northern region. The evening terminator is also well-positioned, optimising the view. You'll need to start observing in the morning sky from 13 March. There is a catch through, as morning Moons are poorly placed at this time of year, hampered by low altitude.

On 13 March, the north polar libration is slight, increasing noticeably as the Moon moves into its waning crescent phase.


Libration favours the northern region of the Moon mid-March, bringing craters such as Hermite (arrowed) into view

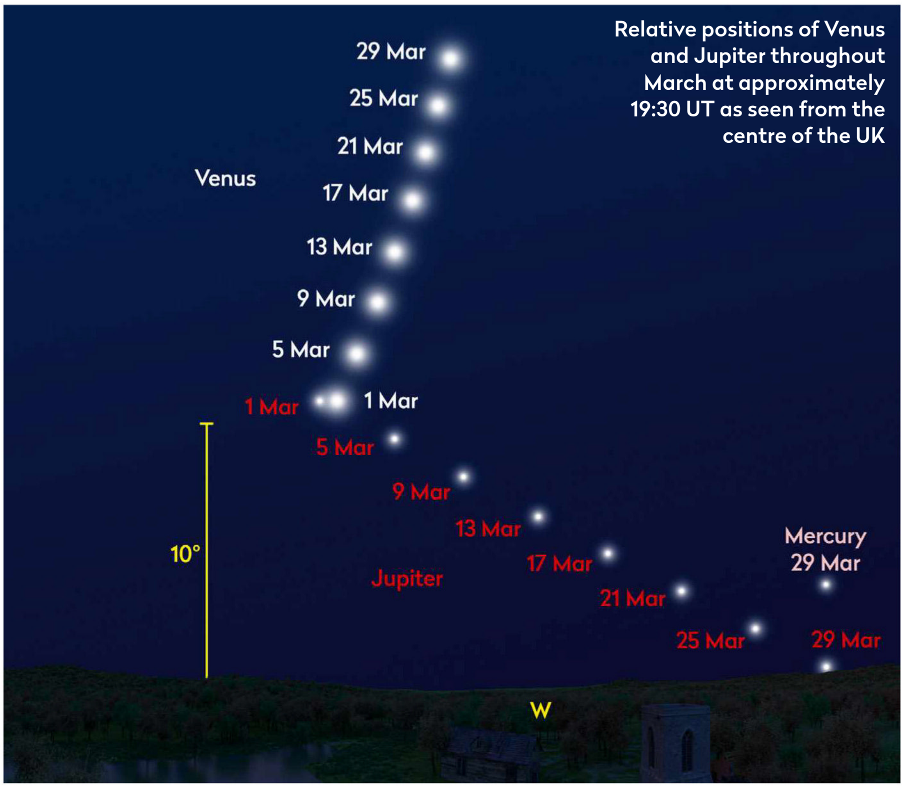
This will bring features such as 111km Hermite and 177km Rozhdestvenskiy into view. Altitude will be an issue, something which highlights why libration timing can be tricky. In order to get a good view, libration needs to be favourable for the area of interest, the phase right, the Moon well-placed and the weather fair.

# THE PLANETS Our celestial neighbourhood in March

## PICK OF THE MONTH

## Venus

**Best time to see:** 31 March, from 1 hour after sunset
**Altitude:** 22°
**Location:** Aries
**Direction:** West
**Features:** Phase, subtle atmospheric shadings
**Recommended equipment:** 75mm or larger




▲ After its close brush with Jupiter on 1 March, Venus remains a brilliant twilight fixture

Mag. –3.9 Venus sits really close to mag. –2.0 Jupiter at the start of March, the two planets appearing 38 arcminutes apart on 1 March and 46 arcminutes apart on 2 March. Using a telescope for the encounter, Venus will be showing an 85%-lit phase and appear 12 arcseconds across, while Jupiter will appear nearly three times larger at 34 arcseconds across. It will be interesting to try to grab a view or photograph of the pair through a telescope with both planets showing their discs. The pair set nearly three hours after the Sun at the start of March.

Venus and the crescent Moon are always a popular sight in the early evening sky; they would be equally as popular when in the morning sky, were it not for the fact that you have to get up early to see such an encounter! A slender 5%-lit waxing crescent Moon appears near Venus on 23 March, with a second chance available on 24 March when the slightly thicker 9%-lit waxing crescent appears even closer to the mag. –3.9 planet.

A second planetary encounter occurs on 30 March but, it has to be said, this event will be less impressive than the Venus–Jupiter conjunction at the start of the month. On 30 March, Venus lies 1.2° from dim Uranus. The magnitude disparity between –3.9 Venus and +5.8 Uranus represents a brightness difference of around 7,500 times.

Throughout the month, Venus can be seen against a truly dark sky, which only helps to emphasise how bright this beautiful planet appears. Its altitude will be low at the start of March. By the end of the month Venus remains above the horizon for 220 minutes after sunset.

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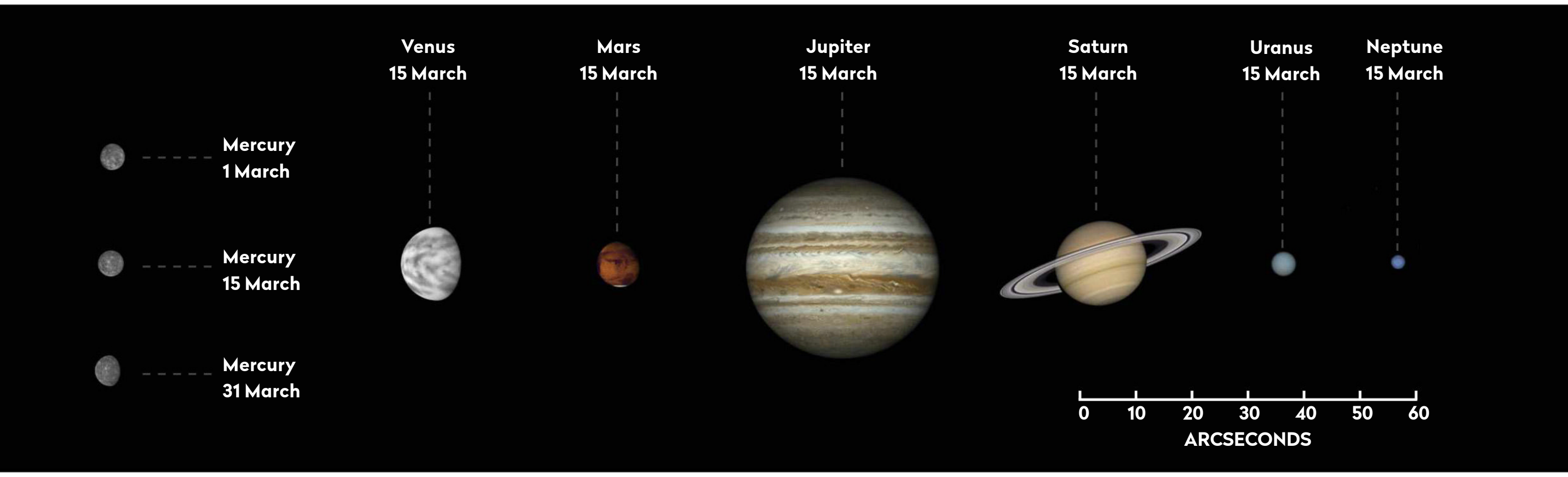
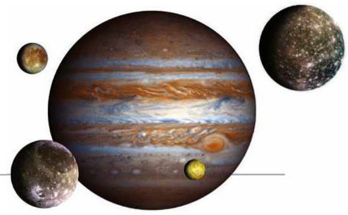
## The planets in March

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





## Mercury

**Best time to see:** 31 March, 40 minutes after sunset
**Altitude:** 6° (low)
**Location:** Pisces
**Direction:** West
Mercury begins March poorly located in the morning sky. Superior conjunction occurs on 17 March, after which Mercury reemerges favourably into the evening sky. On 24 March, mag. –1.5 Mercury sets 40 minutes after sunset.
Mercury and Jupiter are close at the end of the month, appearing 1.5° apart on 27 March. Mercury is mag. –1.3 on this date. By the end of the month, at mag. –1.1, Mercury's separation from the Sun increases and it now appears above Jupiter, setting 85 minutes after sunset.

## Mars

**Best time to see:** 1 March, from 19:25 UT
**Altitude:** 61°
**Location:** Taurus
**Direction:** South
Mars is fading as its distance from Earth increases. On 1 March, the mag. +0.4 evening planet presents a disc 8 arcseconds across through the eyepiece. This is still large enough to present detail through larger scopes, but it is getting harder. By the end of March, Mars shrinks to 6 arcseconds across and dims to mag. +0.9. On 30 March, Mars appears 1.2° from the mag. +5.1 open cluster M35.

## Jupiter

**Best time to see:** 1 March, from 19:00 UT
**Altitude:** 15°
**Location:** Pisces
**Direction:** West
Jupiter puts on an early March naked-eye display with bright Venus. On 1 March, both bright planets appear separated by 38 arcminutes, and while on 2 March they part slightly, they still remain around 0.75° apart. Venus will be at mag. –3.9 and Jupiter at mag. –1.9.

After this, Jupiter rapidly moves into the evening twilight. On the evening of 22 March, Jupiter sits 1.8° above a 1%-lit waxing crescent Moon, visible low above the western horizon 30 minutes after sunset. Jupiter appears 1.5° from mag. –1.3 Mercury on 27 March.

## Saturn

**Unlikely to be seen in the morning sky**
Saturn is a morning planet, badly placed throughout the month and unlikely to be seen.

## Uranus

**Best time to see:** 1 March, from 19:40 UT
**Altitude:** 37°
**Location:** Aries
**Direction:** West-southwest
Uranus's position deteriorates rapidly this month. On 1 March it shines at mag. +5.8 and binoculars are recommended to see it. Uranus has an altitude of 37° as true darkness falls. By the end of March, this value drops to just 12°. Uranus has a close encounter with Venus on 30 March, dim Uranus 1.2° from mag. –3.9 Venus at 20:40 UT. A slender 12%-lit waxing crescent Moon sits slightly less than 2° from Uranus on 24 March, as they both approach the west-northwest horizon.

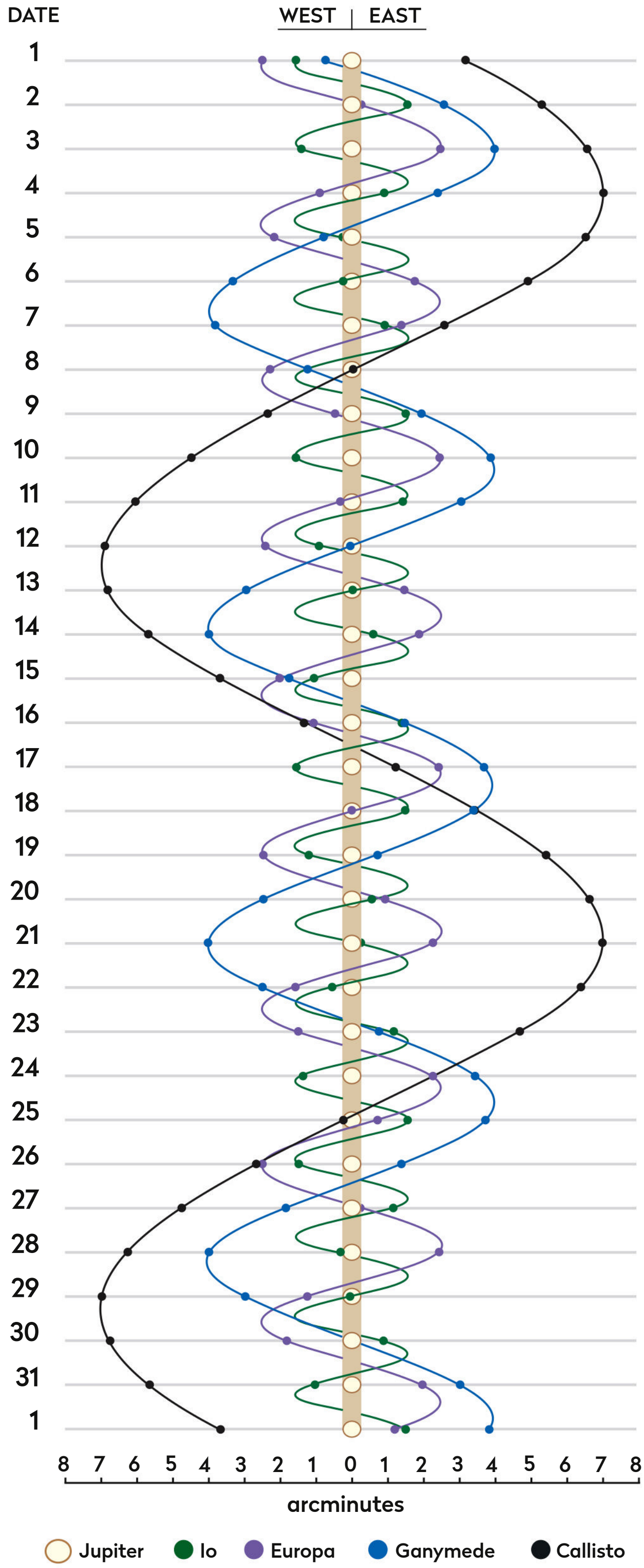
## Neptune

**Not visible this month**
Neptune is in conjunction with the Sun on 15 March and not visible this month.


MORE ONLINE
Print out observing forms for recording planetary events


## JUPITER'S MOONS: MARCH

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 00:00 UT.



# THE NIGHT SKY – MARCH

Explore the celestial sphere with our Northern Hemisphere all-sky chart

## KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- N, E, S, W, 5° — COMPASS AND FIELD OF VIEW
- MILKY WAY

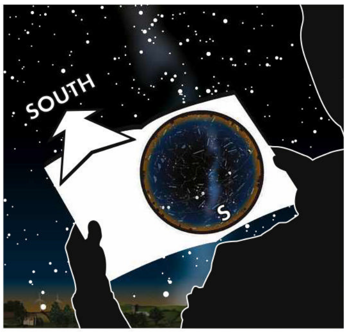
## When to use this chart

**1 March at 00:00 UT**
**15 March at 23:00 UT**
**31 March at 23:00 BST**

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

## How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.




## Sunrise/sunset in March*

| Date | Sunrise | Sunset |
|---|---|---|
| 1 Mar 2023 | 06:59 UT | 17:47 UT |
| 11 Mar 2023 | 06:35 UT | 18:06 UT |
| 21 Mar 2023 | 06:11 UT | 18:24 UT |
| 31 Mar 2023 | 06:47 BST | 19:43 BST |

## Moonrise in March*

**Moonrise times**

| | |
|---|---|
| 1 Mar 2023, 10:53 UT | 17 Mar 2023, 05:09 UT |
| 5 Mar 2023, 15:25 UT | 21 Mar 2023, 06:30 UT |
| 9 Mar 2023, 20:25 UT | 25 Mar 2023, 07:19 UT |
| 13 Mar 2023, 00:29 UT | 29 Mar 2023, 10:37 BST |

*Times correct for the centre of the UK

## Lunar phases in March

| Saturday | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 FULL MOON | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 NEW MOON | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 |

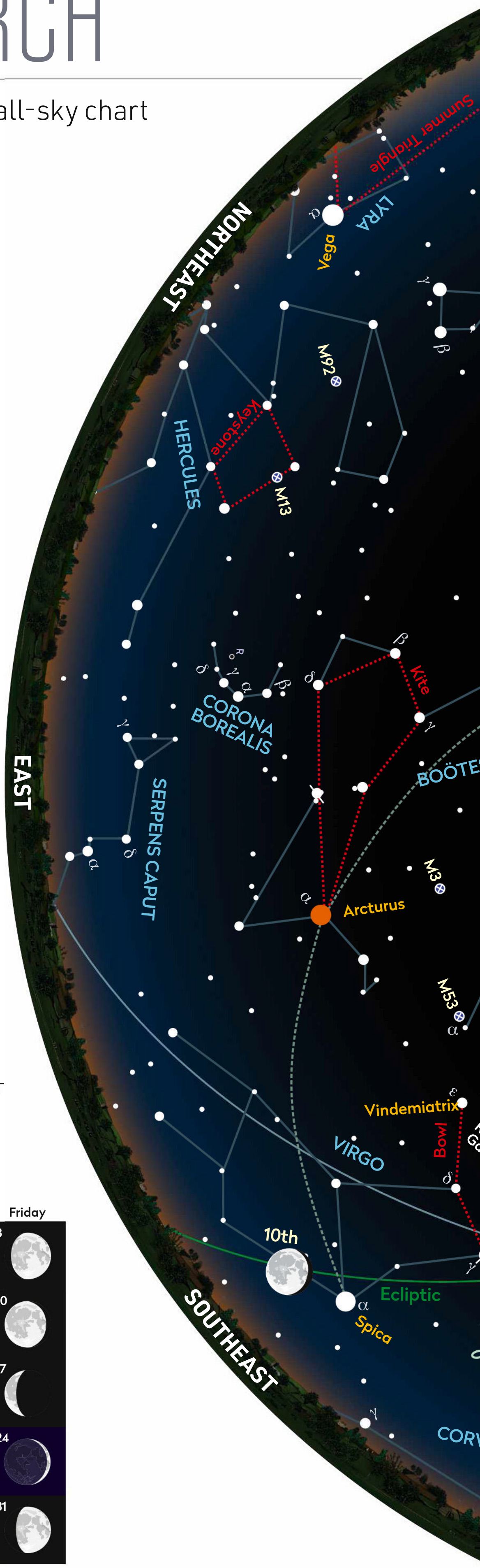



CHART: PETE LAWRENCE

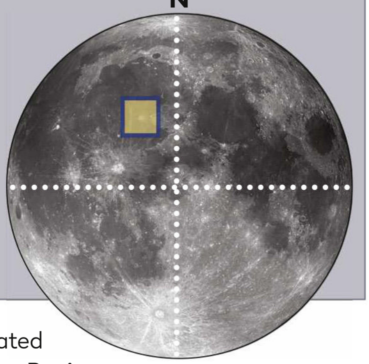

MORE ONLINE

Paul and Pete's night-sky highlights

Southern Hemisphere sky guide

## Timocharis

**Type:** Crater
**Size:** 35km
**Longitude/latitude:** 13.1° W, 26.7° N
**Age:** 1.1–3.2 billion years
**Best time to see:** One day after first quarter (28 February and 1 March) or last quarter (15 March)
**Minimum equipment:** 50mm refractor




**Timocharis** is a sharp-rimmed crater located within the vast 1,250km-diameter **Imbrium Basin**. It lies within the mismatched arc of craters starting at 25km **Theaetetus**, progressing through 55km **Aristillus**, 83km **Archimedes**, 35km **Timocharis**, 30km **Lambert** and concluding with 28km **Euler**. Timocharis lies 550km north-northeast of 93km **Copernicus**, within the extensive Copernican ray system which is easily visible in the southern half of Mare Imbrium.

An appreciable ejecta rampart surrounds Timocharis's polygonal rim, fairly symmetrical in appearance and stretching for around 30km from the main rim edge. Its rim appears well-defined and internally the initial wall fall-off is extremely steep down to a 'shelf'. From there, the elevation falls in an irregular fashion towards the main crater floor and central mountain complex. The crater's depth from rim edge to floor is around 3km.

The central mountain complex is interesting because it doesn't exist – when you observe Timocharis, it soon becomes evident that the mountain region is occupied by a depression. This appears a particularly well-targeted impact, the resulting craterlet completely obliterating Timocharis's central mountain.

As a result of the crater's internal up and downs, Timocharis is fascinating to observe when either the morning or evening terminator is nearby. The low Sun angle really helps pick out the detail in the inner terraces and, with larger instruments, the 4.4km depression at the crater's centre.

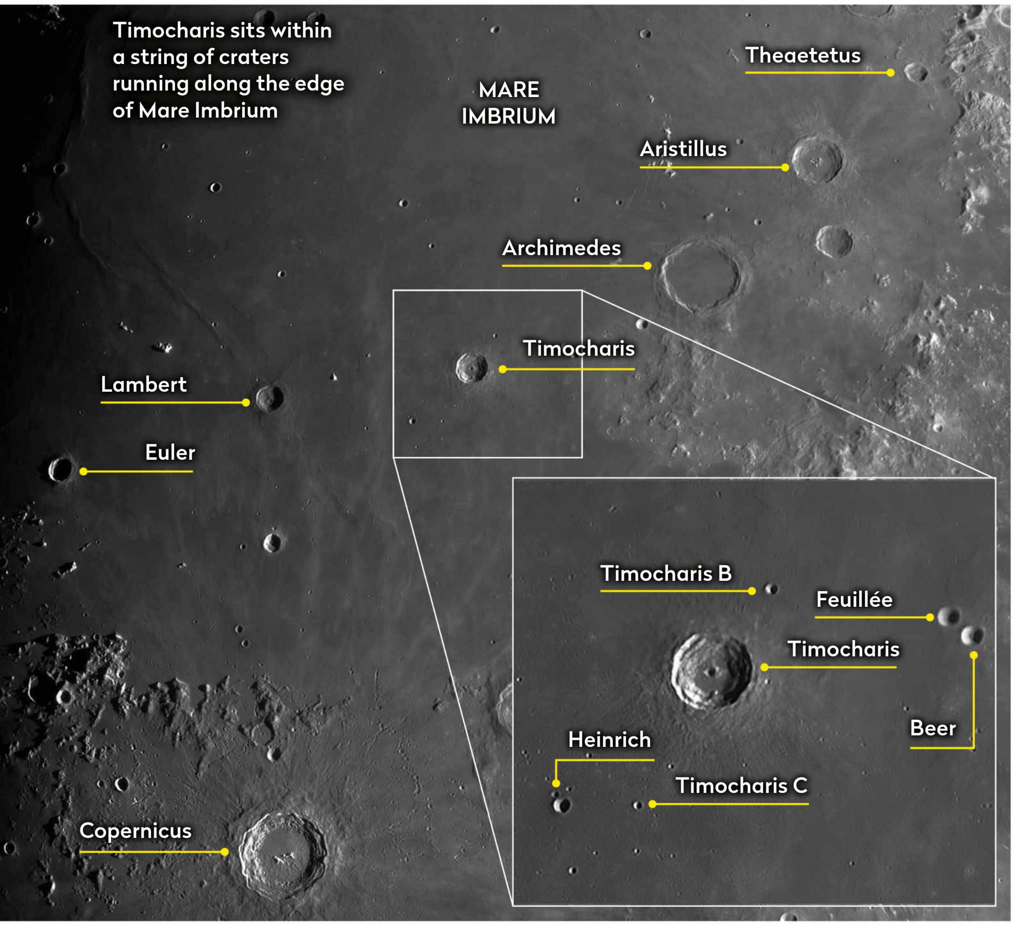
***A low Sun will help pick out the 4.4km depression at the centre***

A transient lunar phenomenon, or TLP, was the term used to describe short-lived events that changed the appearance of the Moon's surface; this could be changes in colour or brightness of specific regions. Recorded for at least 1,000 years, transient lunar phenomenon reports have sometimes been controversial. Reports were often submitted from a single observer and met with a degree of scepticism. They are less common today, but still reported and coordinated. The abbreviation now tends to relate more to the growing study of lunar impact flashes.

A couple of notable TLP events are associated with Timocharis. One relates to the observer David Barcroft (1897–1974) who reported the crater to be "filled with vapour and very indistinct near full Moon". Another relates to VA Firsoff who reported a red glow inside Timocharis on 8 and 10 October 1954. This was followed by the crater showing a blue brightening on 3 August 1955, an event observed through a blue filter. Whether the observed phenomena were real is uncertain, but it's fair to say that TLP events are expected to occur on the Moon, just not at the frequency at which they were observed.

More conventional views of Timocharis against the lava of Mare Imbrium reveal few features in the crater's immediate vicinity. A tiny 2.2km craterlet sits just outside the rim edge to the east. 43km northeast of Timocharis's centre is 5km bowl-shaped **Timocharis B**. Look in the other direction, 64km to the southwest and you'll arrive at 4km **Timocharis C**. This is located to the east of 8km **Heinrich**.

PETE LAWRENCE X 3



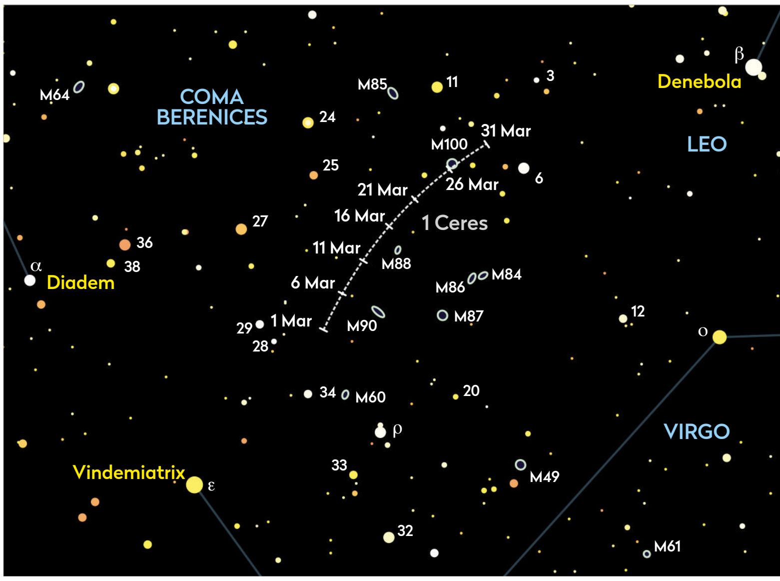

Timocharis sits within a string of craters running along the edge of Mare Imbrium

# COMETS AND ASTEROIDS

## Passing north of the Virgo Cluster, dwarf planet Ceres is trackable all month

Dwarf planet Ceres reaches opposition on 23 March. Currently moving through southern Coma Berenices, Ceres will appear like a seventh-magnitude star throughout March, making it easy to track using binoculars or a small telescope. On 1 March it shines at mag. +7.3, reaching its peak brightness of +7.1 between 14 and 29 March. Close to the border between Coma Berenices and Virgo, this is galaxy territory, the dwarf planet tracking along the northern edge of the Virgo Cluster. At 00:00 UT on 16 March, Ceres lies 40 arcminutes north of the mag. +9.4 galaxy M88. Later, at 01:00 BST (00:00 UT) on 27 March, it passes across the similarly bright mag. +9.3 galaxy M100 – although instruments that only show the core of this beautiful spiral will more likely show Ceres making a close approach rather than transiting the faint spiral arms. A good technique to record Ceres is to make a drawing or take a photo of the suspected field over several nights. Weather permitting, this should reveal Ceres's movement as it tracks against the background stars.

Ceres was the first identified asteroid. Discovered on 1 January 1801 by Italian monk Giuseppe Piazzi, as the first asteroid it was designated to become 1 Ceres. In modern times, although it is still referred to in this way, it has been reclassified as a dwarf planet. Piazzi discovered Ceres by noting the existence of an additional, uncharted star. Observing over consecutive nights, the 'star' appeared to move, raising suspicions that it was something non-stellar. Illness and bad weather got in the way of further observations until 24 January 1801, when the motion of this mysterious object was sufficient for Piazzi to determine that it was located within the Solar System.




▲ Ceres's path takes it across spiral galaxy M100 on 26/27 March

# STAR OF THE MONTH

## Zosma, the rump of Leo the Lion

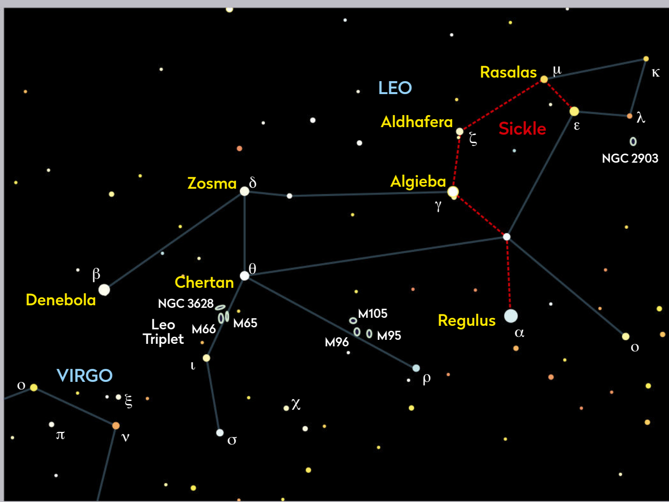
Zosma is a mag. +2.5 star marking the point on the top of Leo's body that connects to the Lion's tail. This is the IAU-approved name for Delta (δ) Leonis, derived from the Greek word for 'girdle'. However, its Arabic name, Dhur, meaning 'the lion's back', might have been more appropriate.

It's a main sequence star with a spectral classification A4 V: a white (A4) main sequence dwarf (V). It is 2.1 times larger than the Sun and 15 times more luminous. Unlike the Sun's leisurely rotation velocity of 2km/s, Zosma rotates with a projected rotational velocity of 180 km/s. This is uncorrected for the inclination of the rotational axis; correct the angle so the axis would be at right angles to our line of sight and the speed would be around 280km/s. As a consequence, up close Zosma would show a noticeable equatorial bulge.

Parallax measurements put the star at a distance of 58.4 lightyears from the Sun. Direct measurements of Zosma's proper motion – direction and velocity through space – show it is probably part of a collection of stars known as the Ursa Major Moving Group. This group would have formed in the same location together around 500 million years ago.

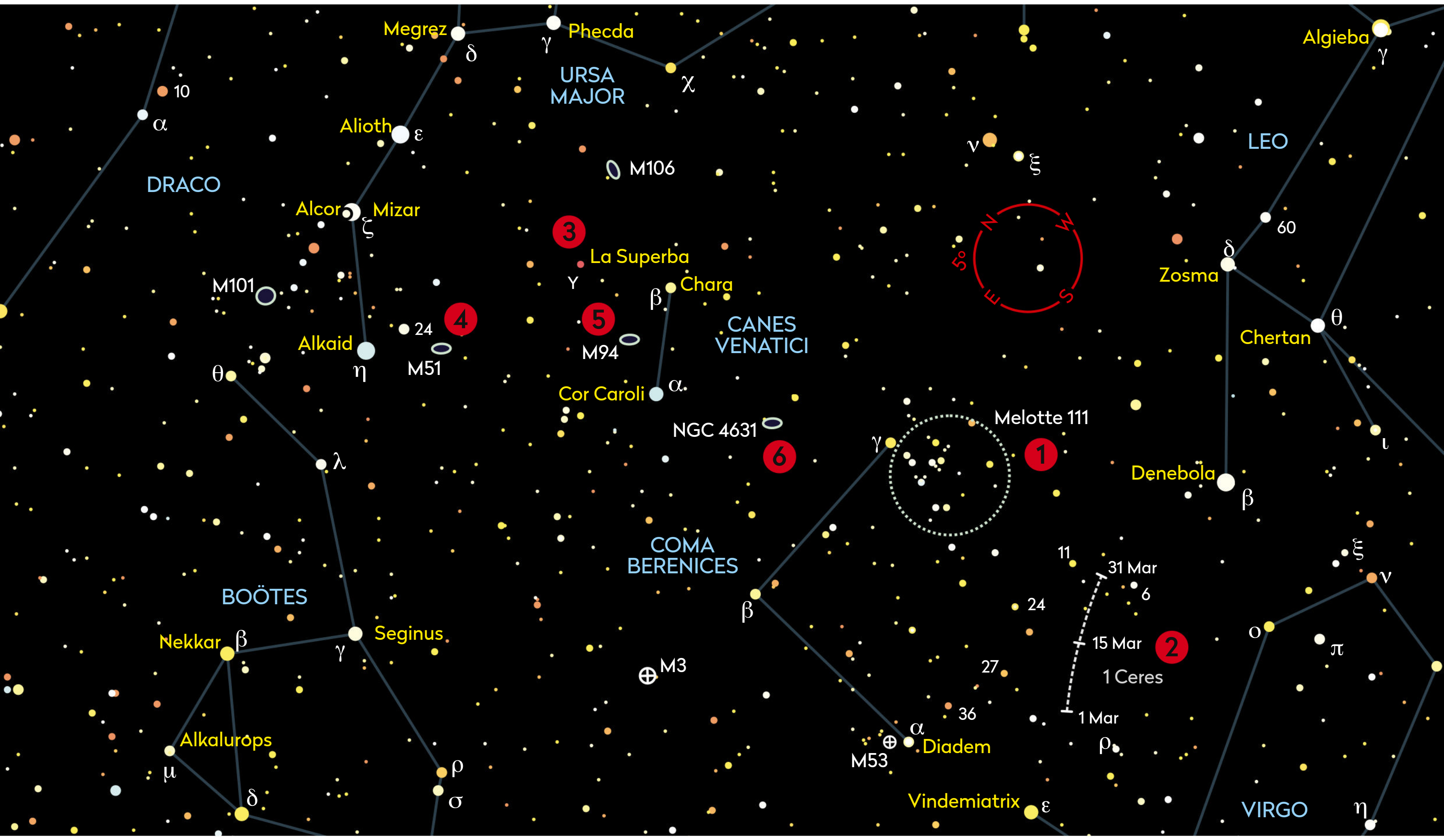
Zosma's hydrogen fusion period is around 1 billion years and consequently we know the star is about halfway through its 'normal' life cycle. At the end of this cycle its helium core will shrink and its outer layers expand, causing it to become an orange giant.

▼ Easy to see with the naked eye, Zosma sits in an unglamorous spot at the foot of Leo's tail



# BINOCULAR TOUR With Steve Tonkin

This month we're prowling for targets with the hunting dogs, Canes Venatici




### 1. Melotte 111

**10x 50** The Coma Berenices Cluster, Melotte 111, is one of the finest celestial sights for binoculars, extending for nearly 6° and filling the view of 10x50 binoculars. You can see it with your naked eye as a misty patch between mag. +2.9 Cor Caroli (Alpha (α) Canum Venaticorum) and mag. +2.1 Denebola (Beta (β) Leonis). Look for the inverted 'V' of the cluster's brighter stars, with mag. +4.3 Gamma (γ) Comae Berenices at its apex. ☐ **SEEN IT**

### 2. Ceres

**10x 50** Ceres is the only dwarf planet that is visible in binoculars. At the beginning of the month, you will find it a little more than 3° north of mag. +4.9 Rho (ρ) Virginis, shining at mag. +7.4. It moves westward through the northern part of the Virgo–Coma cluster of galaxies, reaching a peak magnitude of +7.1 at opposition (when it is directly opposite the Sun) on 21 March, then declining to mag. +7.2 by the month's end. ☐ **SEEN IT**

### 3. La Superba

**10x 50** Locate mag. +4.2 Chara (Beta (β) Canum Venaticorum) and pan 4.5° towards mag. +2.2 Mizar (Zeta (ζ) Ursae Majoris) where there lies a distinctive red-orange star (it looks a deeper orange in larger apertures). This is Y CVn, a cool carbon star whose magnitude varies from +6.3 to +4.7, with a period of about 160 days. The name La Superba refers to its spectrum, not its visual appearance. ☐ **SEEN IT**

### 4. The Whirlpool Galaxy, M51

**10x 50** Our first galaxy is very easy to find and, because of its high surface brightness, is also quite easy to see. Imagine that a line from Mizar to mag. +1.9 Alkaid (Eta (η) Ursae Majoris) is the stem of an upper case letter 'L'. M51 lies at the end of the foot of this imaginary 'L', 3.5° from Alkaid. If you use averted vision, can you detect that the glow of these 100 billion suns is slightly elongated? ☐ **SEEN IT**

### 5. M94

**15x 70** Imagine a line joining Cor Caroli to Chara, and from halfway along this line go 2° in the direction of Alkaid. Here, possibly needing averted vision until you learn to recognise it, you'll find the 23-million-year-old light from the spiral galaxy M94. Like all galaxies, it benefits greatly from dark, transparent skies, but it is usually quite easy to see once it rises above any low-level skyglow. ☐ **SEEN IT**

### 6. The Whale Galaxy, NGC 4631

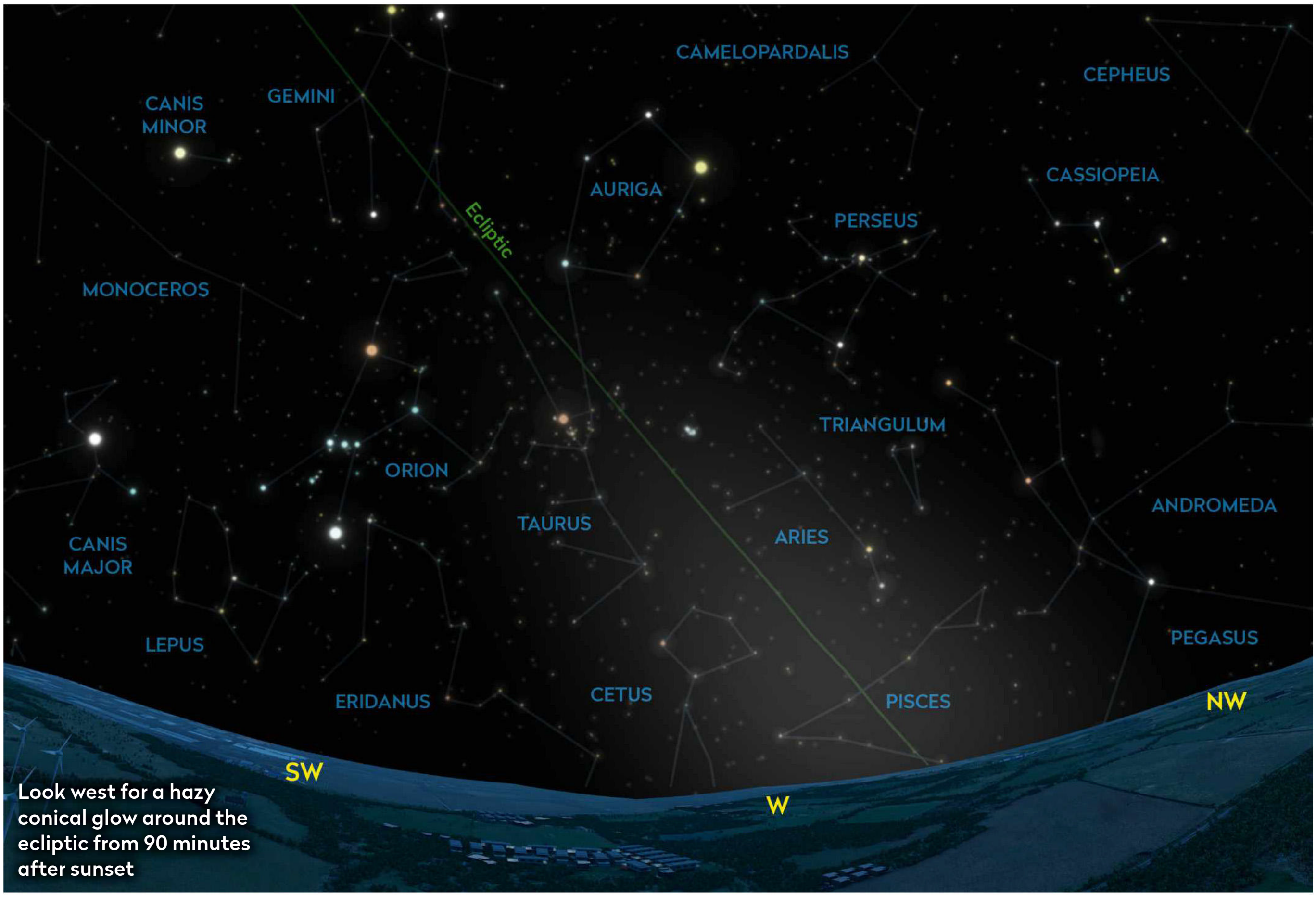
**15x 70** Our final target has no nearby markers to help locate it, but it's very close to the middle of a line joining Cor Caroli to Gamma Comae. It's a bit fainter than our other two galaxies, making it a bit of a challenge in 70mm binoculars, so you may need averted vision. What you will see is an east–west streak of light, but probably not the slight distortion that gives it its common name. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

# THE SKY GUIDE CHALLENGE

Can you spot the ethereal and elusive Zodiacal Light in March's evening skies?



Look west for a hazy conical glow around the ecliptic from 90 minutes after sunset

The Zodiacal Light isn't a commonly observed phenomenon from the UK. We don't often have the darkness that's required to see it and it's not always obvious even when it's there, appearing large, faint and subtle.

Its origin is thought to be from short-period 'Jupiter-family' comets. The tiny particles of comet dust released from these objects orbit in the plane of the Solar System. When sunlight interacts with the 10–300-micron-sized particles, from Earth we sometimes see its presence after sunset or before sunrise. A high ecliptic angle with the prevailing horizon is preferable for spotting the Zodiacal Light, and during March that ecliptic angle is optimal after the Sun has set, when it's the western horizon that is important. Conversely, for pre-dawn appearances the optimal place and time is the eastern horizon around late September.

In order to see this ghostly glow, there are several factors that need to align. Dark skies are a must. If you live in a light-polluted area, as most of us sadly do, you may need to travel elsewhere. Natural light pollution should be avoided too, so time any attempts for when the Moon is out of the way. In the spring this will typically be when it's in the waning gibbous phase through to the very earliest of the waxing crescents. For the next period, the optimal date ranges are 12–23 March and 9–22 April. The weather needs to be good too, with a clear, crisp spring sky. High, hazy cloud will act as a perfect filter for the Zodiacal Light, so watch out for this too.

***To see this ghostly glow, dark skies are a must so you may need to travel***

When visible, the Zodiacal Light presents itself with a distinctive conic shape. The cone's vertical axis is tilted relative to the horizon, running along the ecliptic with the lower edges of the cone bulging outward. The best time to try to see the Zodiacal Light is during the 90-minute window that starts 90 minutes after sunset. For a directional guide, follow the line of the planets, an imaginary line from Venus through to Mars conveniently defining the line of the ecliptic for you.

If you fail to see the Zodiacal Light visually, a wide-angle camera pointed in the directions mentioned above at the correct times may fare better. The camera should be set to produce a relatively deep but not overexposed sky, and doesn't need to track, a fixed tripod being fine.

A time-lapse sequence can be useful here because it can be played back to show whether the characteristic Zodiacal Light shape was really present, even if you couldn't see it visually. Don't forget to let us know if you do manage to see or photograph it.

# DEEP-SKY TOUR

Set your sights on the twins as our March tour takes us to six gems in Gemini

**1 NGC 2371/72**

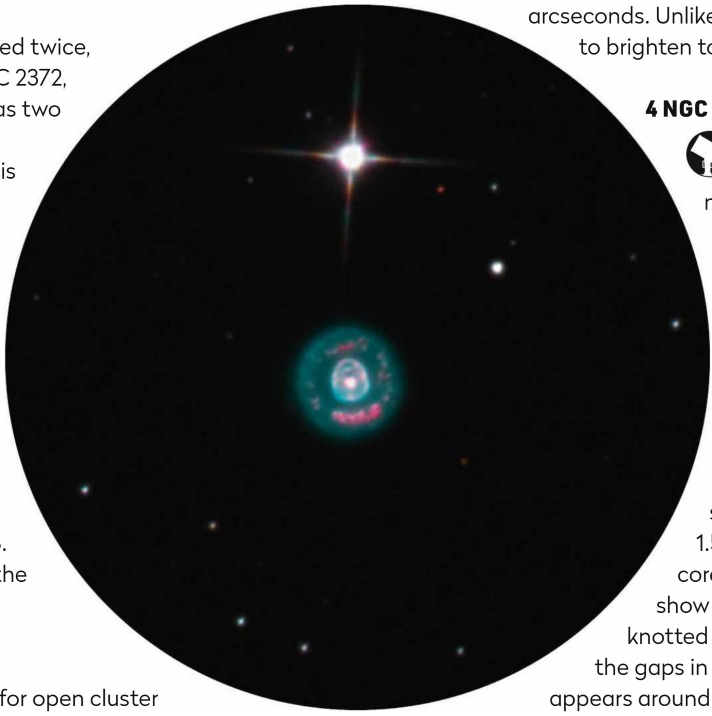
NGC 2371 is catalogued twice, as NGC 2371 and NGC 2372, a consequence of it appearing as two separate objects. A mag. +11.3 planetary nebula, NGC 2371/72 is located 1.7° north of mag. +3.8 Iota (ι) Geminorum. A 150mm scope shows a faint haze with an embedded star-like feature. A 250mm scope reveals the dual nature, two lobes connected by a haze, the southwestern lobe brighter and tighter with a star-like core. The central star sits between lobes, requiring a large scope to see at mag. +14.8. The pair are fittingly known as the Gemini Nebula. ☐ **SEEN IT**

**2 NGC 2331**

Head 4.6° southwest for open cluster NGC 2331. Also lying 3.1° south and a fraction west of mag. +4.4 Tau (τ) Geminorum, NGC 2331 is probably best located via mag. +5.8 47 Geminorum, the cluster 1.1° to the west-northwest of this star. NGC 2331 has an integrated magnitude of +8.5, its members scattered across an area slightly larger than the apparent radius of the Moon. It's not overly concentrated though and fairly easy to overlook. A 100mm scope reveals around 20 individual stars over an area 19 arcminutes in diameter. NGC 2331 was discovered in 1785 by the English astronomer William Herschel using an 18.7-inch reflecting telescope. ☐ **SEEN IT**

**3 NGC 2341/42**

NGC 2341 and NGC 2342 are located 6.7° south and a fraction east of NGC 2331. Your best guide is mag. +4.0 Mekbuda (Zeta (ζ) Geminorum), NGC 2341 lying 1.2° east of this star. Both objects are galaxies, NGC 2342 being slightly brighter at mag. +12.6. It sits 2.6 arcminutes northeast of mag. +13.7 NGC 2341. Through a small instrument, only NGC 2342 is obvious. A 300mm scope shows an oval glow 1.0 x 0.7 arcminutes in size. The glow only appears to have a very subtle core brightening. NGC 2341 has a similar surface brightness, appearing round in shape with an apparent diameter of 20 arcseconds. Unlike NGC 2342, NGC 2341 appears to brighten towards a tiny core. ☐ **SEEN IT**



▲ **Larger scopes will reveal the bright region around the central dying star of planetary nebula NGC 2392**

**4 NGC 2339**

Our next target is NGC 2339, another galaxy. This one is marginally brighter than NGC 2342, with an integrated magnitude of +11.6. It's located 2.1° south-southeast of Mekbuda and best seen with larger instruments. It was discovered by William Herschel in 1789 and has a low surface brightness due to being face-on. A 250mm scope shows a roughly circular 1.5-arcminute glow with a bright core. A 300mm scope starts to show mottling, caused by the knotted spiral arms contrasting with the gaps in between them. The core appears around a third of an arcminute across through such an instrument. ☐ **SEEN IT**

**5 NGC 2392**

Our penultimate object is one of the more famous deep-sky targets in Gemini: NGC 2392. This bright planetary nebula has an integrated magnitude of +9.2. Visually it has a similar apparent size to Jupiter, covering an area 47 x 43 arcseconds. It's found 2.3° east-southeast of Wasat (Delta (δ) Geminorum), 0.6° southeast of mag. +5.2 63 Geminorum. The nebula sits 1.4 arcminutes south of a mag. +8.2 star. A 150mm scope shows it easily, along with its bright mag. +10.5 central star. It appears blue through a 250mm scope and mottled at high magnification. Larger apertures show an extended bright region around the central star. ☐ **SEEN IT**

**6 NGC 2420**

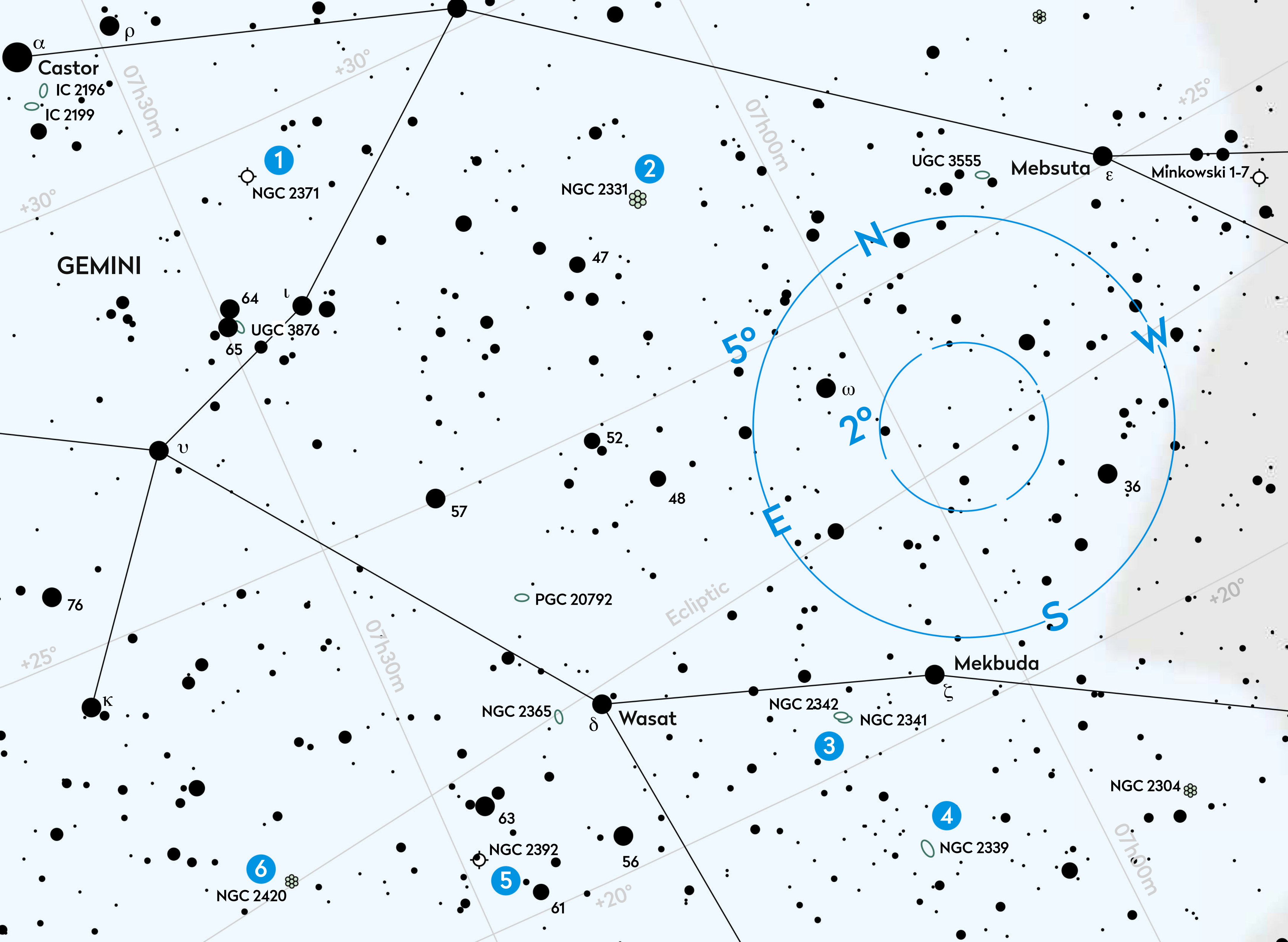
NGC 2420 is an eighth-magnitude open cluster visible in small scopes as a 10-arcminute glowing smudge, 2.3° east-northeast of NGC 2392. It sits midway between two ninth-magnitude stars aligned north–south, and two eighth-magnitude stars aligned northeast–southwest. Larger aperture resolves more stars in the glow, a 250mm scope showing 20 members scattered against a 6 x 4-arcminute mottled, elliptical haze. A 300mm scope almost doubles the number of stars seen, increasing the cluster's apparent diameter to around 8 x 6 arcminutes. Astrophotography can resolve the cluster stars with relative ease, revealing a cluster occupying much of the 13-arcminute distance between the two north–south aligned ninth-magnitude stars mentioned earlier. ☐ **SEEN IT**

**This Deep-Sky Tour has been automated**
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.


More **ONLINE**

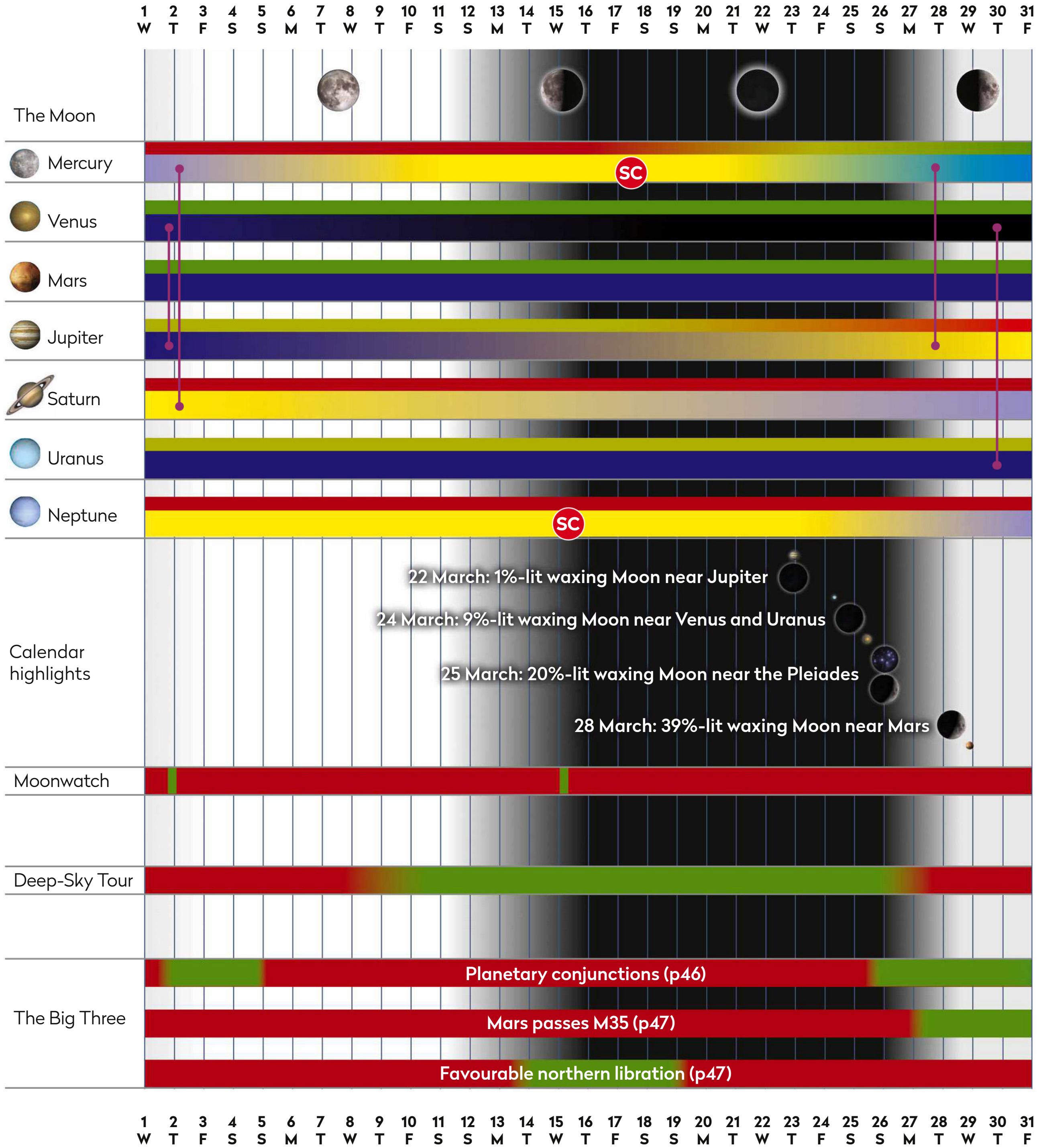
**Print out this chart and take an automated Go-To tour. See page 5 for instructions**

MICHAEL DEGER/CCDGUIDE.COM, CHART BY PETE LAWRENCE



Castor
IC 2196
IC 2199
GEMINI
NGC 2371
UGC 3876
NGC 2331
UGC 3555
Mebsuta
Minkowski 1-7
PGC 20792
Ecliptic
Mekbuda
Wasat
NGC 2365
NGC 2342
NGC 2341
NGC 2304
NGC 2339
NGC 2392
NGC 2420
N
S
E
W
5°
2°
07h30m
07h00m
+30°
+25°
+20°

# AT A GLANCE How the Sky Guide events will appear in March




## KEY

**Observability**

Optimal | Poor

**Best viewed**

Morning twilight | Daytime | Evening twilight | Night

**Sky brightness during lunar phases**

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

Meteor radiant peak

Planets in conjunction

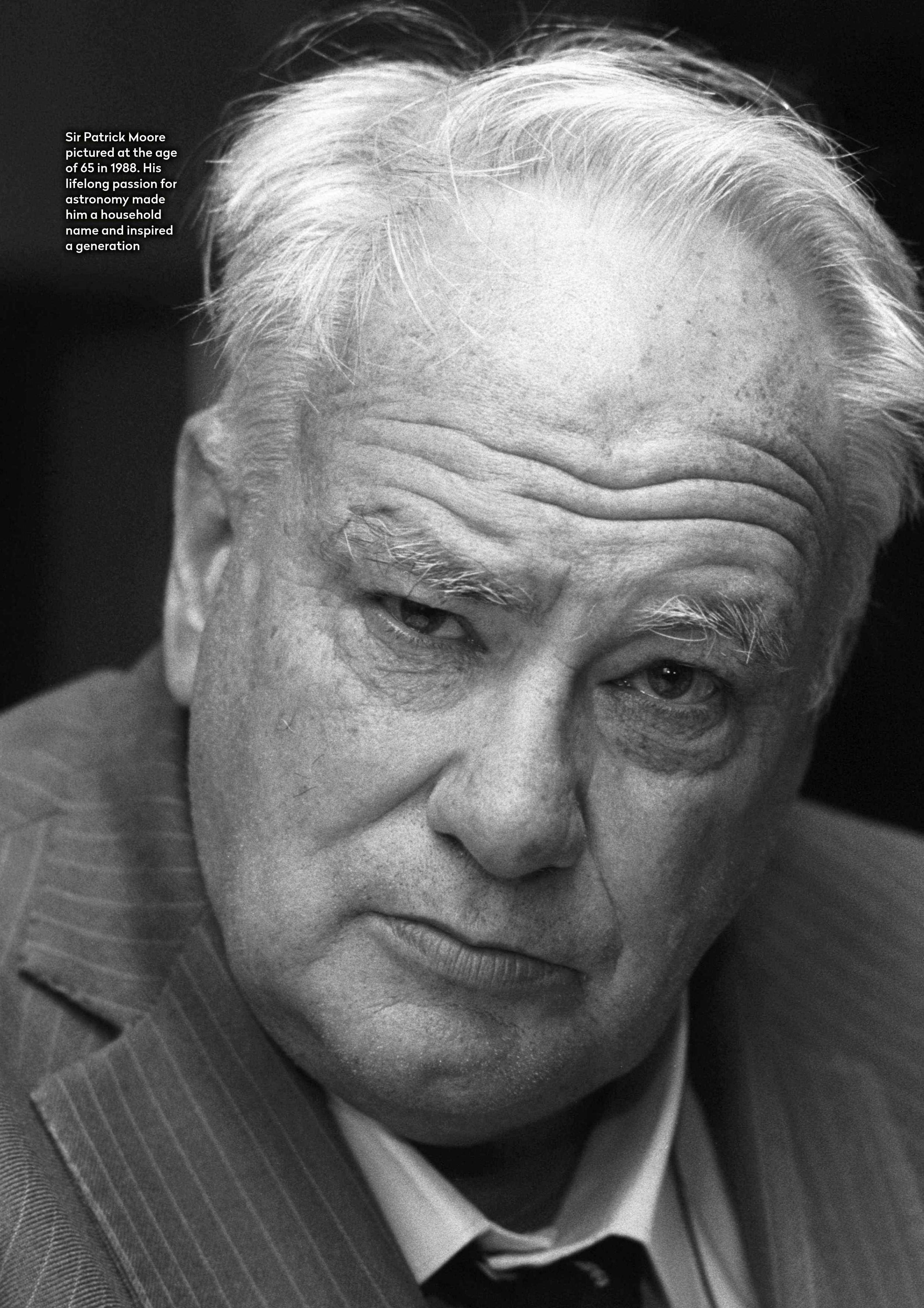
Full Moon

First quarter

Last quarter

New Moon

CHART BY PETE LAWRENCE



Sir Patrick Moore pictured at the age of 65 in 1988. His lifelong passion for astronomy made him a household name and inspired a generation

# Patrick Moore

## A PASSION FOR SPACE

On the 100th anniversary of his birth, we look back on the life of Britain's best-loved amateur astronomer

Patrick Moore did more than anyone in history to get people interested in the stars. As the face of *The Sky at Night*, he introduced millions to the wonders of the night sky and in the process set a television record, by becoming the world's longest-serving presenter on the same programme.

Thanks to his passion for astronomy, ruffled appearance and slightly eccentric manner, Patrick's persona made him a celebrity among the general public and a household name in the UK, where he was the only amateur astronomer most people had heard of, while his books and magazine articles gained him recognition the world over.

Alfred Patrick Caldwell-Moore was born on 4 March 1923, the only child of Captain Charles Trachsel Caldwell-Moore MC, who had served in the army, and Gertrude Moore (née White), who trained as an opera singer in Italy.

Patrick grew up in Sussex – first in Bognor Regis and later in East Grinstead. He went to prep school for one term when he was eight, but his formal schooling was limited by the heart problems he suffered up to the age of 16. While this seemed to have put paid to any thoughts of going to Eton College and the University of Cambridge, it did leave him plenty of time for other pursuits.

He could play the piano by the age of eight and had composed his own Viennese waltz by the age of 10. At 13, a chance win on the football pools enabled him to buy a xylophone. The following year he gave a solo performance on it at a theatre in East Grinstead. Music was to play a big part in his later life, and he once said that one of his biggest regrets was not taking it more seriously.

Patrick's interest in astronomy started early. Hooked at the age of six, after reading GF Chambers's 1898 book *The Story of the Solar System*, he resolved to learn a new constellation each night and bought a pair of binoculars to explore the heavens. Such was his new-found passion that a family friend proposed him for membership of the British Astronomical Association (BAA). At the age of 11, he became its youngest member and would go on to become its president 50 years later.

### Early promise

Patrick's first big break arrived in the form of WS Franks, an astronomer who operated the privately owned Brockhurst Observatory in East Grinstead. Patrick was just 14 years old when he was asked to take over the running of the observatory after Franks's death. When he wasn't showing invited guests the wonders of the night sky, he used its 6-inch telescope to study the Moon.

His observations of lunar craters were so detailed that he wrote them up in a paper and presented them at a BAA meeting. It was the start of ▶

PA IMAGES/ALAMY STOCK PHOTO

▲ **When war broke out, a strong sense of duty impelled the 16-year-old Patrick to join up with the RAF. He had to lie about his age and ask a friend to stand in for his medical**

SIR PATRICK MOORE HERITAGE TRUST/COURTESY OF THE EXECUTORS, BBC X 2

▶ Patrick's long obsession with the Moon. Not long afterwards, another trademark quirk was born. When an optician told him his eyesight was lacking in one eye, he insisted on wearing a monocle rather than a frame with one blank lens.

Despite the heart problems that beset him, he passed school exams with the help of tutors and was due to take up a place at the University of Cambridge when the Second World War broke out. He joined the RAF, despite lying about his age (he was only 16) and getting a friend to stand in for him at his physical examination. He rarely spoke about his wartime experiences, but it is known that he was a navigator on bombing raids to Germany, rising to the rank of flight lieutenant. Astronomy know-how came in handy, enabling him to navigate by the stars using a sextant when the night skies were clear.

His deepest scar from the war was the death of his fiancée Lorna, killed by a German bombing raid in 1943. Such was the pain of the tragedy that he never entered into another relationship. He once commented in an interview for *This is London* magazine, "I would have liked a wife and family, but it was not to be." He did, however, take several godsons under his wing – some being the children of late friends.

After the war, he decided to work as a teacher in order to save up enough money to take up his place at Cambridge. He worked first at a prep school for boys in Woking and then at Holmewood House in Tunbridge Wells. It was while teaching that he set up a 12.5-inch reflecting telescope at his home in East Grinstead and recommenced his studies of the Moon.

His in-depth lunar knowledge was to serve him well when it came to establishing a new career. As a boy he'd learned to type by copying a 60,000-word book about the Moon by WH Pickering. In 1952, he wrote his own book, *Guide to the Moon*, later renamed *Patrick Moore on the Moon*, on a 1908 Woodstock typewriter. The book was such a success that it was reprinted before it was even published, and ran to eight subsequent editions. With his writing career taking off, he made the decision to leave Holmewood House and penned a series of science fiction novels with titles such as *The Master of the Moon*; hundreds of books and countless newspaper and magazine articles followed.

## The life of Patrick Moore

**1923** Patrick is born on 4 March. Family moves to Bognor, West Sussex

**1929** Hooked on astronomy after reading *The Story of the Solar System*

**1931** Acquires a 1908 Woodstock typewriter and learns to touch-type

**1934** Becomes youngest member of British Astronomical Association

**1937** Takes over the privately owned Brockhurst Observatory

**1939** Signs up for RAF, foregoing a place at the University of Cambridge

**1940** Meets Albert Einstein and Orville Wright in New York

**1943** Fiancée Lorna, a nurse, dies when a bomb hits her ambulance

**1945** Returns from RAF service; family moves to East Grinstead

**2001** Receives BAFTA award for outstanding contribution to TV

**2001** Knighted by then Prince Charles at Buckingham Palace

**2001** Made Honorary Fellow of the Royal Society

**2002** Helps to open the South Downs Planetarium, Chichester

**2003** Publishes auto-biography, *80 Not Out*

**2004** Sets record for longest-serving presenter on the same programme

**2004** Salmonella causes him to miss *The Sky at Night* for the first time ever

**2005** Becomes Editor Emeritus of new *BBC Sky at Night Magazine*

**2012** Dies at the age of 89 at his home in Selsey, West Sussex

▲ *The Sky at Night* first aired on 24 April 1957. Along with Patrick, a bright, twin-tailed comet was the star of the show

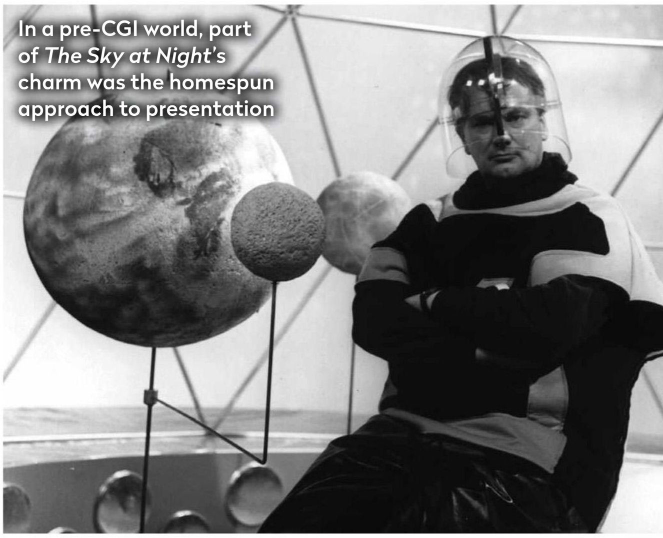
By the mid-1950s, Patrick was no stranger to appearing on TV and radio programmes as an expert astronomer. One television appearance was to prove particularly fortuitous. During one of the regular outbreaks of flying saucer sightings, he was asked to argue the case against alien visitations in a live BBC TV debate. The programme's producer, Paul Johnstone, was impressed by Patrick's performance and soon sounded him out about being the frontman of a new astronomy TV show in development, called *Star Map*.

## Hitting the small screen

The programme first aired at 10:30pm on 24 April 1957 with a new name, *The Sky at Night*. The first show was broadcast live from London's Lime Grove studio, in black and white on the BBC's only channel, and ran for 15 minutes. Patrick later said he was grateful to the twin-tailed comet Arend–Roland – the topic of that first show – which had reached naked-eye brightness around the date of the broadcast.

To begin with, *The Sky at Night* was broadcast on a trial basis, but it quickly became a monthly fixture. One factor in its early success was undoubtedly the burgeoning public interest in all things space-related. The first-ever artificial satellite, Sputnik 1, was launched into orbit in October that same year and the pace of progress was accelerating rapidly. *The Sky at Night* was broadcasting at just the right time in October 1959, when the Russian probe Lunik 3 was orbiting the Moon. Patrick was able to show viewers the far side of the Moon for the first time.

With *The Sky at Night* occupying some of his daylight hours, Patrick continued his astronomy by night. An active member of the BAA, he was at one time director of sections devoted to observing Venus, Mercury and the Moon. And it was the Moon where his observations proved the most valuable. Patrick used sketches by himself and another amateur astronomer, Percy Wilkins, to produce a large map of the Moon's surface. So detailed was it that the ▶



In a pre-CGI world, part of *The Sky at Night's* charm was the homespun approach to presentation

**1945** Joins the teaching staff of Holmewood House prep school, Kent

**1946** Observes mare ('sea') on Moon's limb; names it Mare Orientale

**1953** Publication of his first book, *Guide to the Moon*

**1957** Appears in a live televised debate on UFOs

**1957** First episode of *The Sky at Night* is broadcast on 24 April

**1959** Broadcasts first pictures of the far side of the Moon

**1964** Becomes director of the BAA's lunar section

**1965** Moves to N. Ireland to become director of Armagh planetarium

**1968** Appointed to the Order of the British Empire (OBE)

**1968** Leaves Armagh and sets up home in Selsey, West Sussex

**1969** Takes part in live BBC broadcast of first Moon landing

**1969** Publication of his book *Moon Flight Atlas*, which becomes a bestseller

**1971** Appears on the *Morecambe and Wise Christmas Special*

**1972** Covers last Apollo mission live from Cape Canaveral

**1981** His mother, Gertrude, dies at the age of 94

**1984** Elected president of the British Astronomical Association

**1992** Stars as the Games-Master in Channel 4 series on video games

**1995** Has Caldwell Catalogue published in US magazine *Sky & Telescope*

# Patrick's telescopes

From a 3-inch refractor to a 15-inch reflector, Patrick owned a range of instruments throughout his life

**◀ 3-inch brass refractor**
His first telescope, bought at age 11, was this Broadhurst Clarkson 3-inch refractor on a pillar-and-claw mount. His first paper was based on the observations he made with it. It was restored in 2008 by Telescope House, the retail arm of the same makers who sold it to Patrick in the 1930s.

**12.5-inch reflector ▶**
Purchased after the Second World War, Patrick's first reflector ended up with a Henry Wildey mirror and sat atop a Ron Irving altazimuth mount. Housed in a run-off observatory, Patrick used it to map the Moon, including finding and naming the Mare Orientale in 1946.

**◀ 8.5-inch reflector**
When the Royal Greenwich Observatory moved to Herstmonceux, East Sussex, in the early 1950s, Patrick bought this surplus scope, an 8.5-inch With-Browning reflector. He housed it in an octagonal observatory. It was almost blown away by a tornado in 1998.

**5-inch refractor ▶**
Acquired in the 1960s, this was made by the famous 19th-century telescope-maker Thomas Cooke. Its mount was a Charles Frank equatorial design and it was housed in a run-off-roof observatory. It was restored by telescope craftsman Steve Collingwood.

**◀ 15-inch reflector**
Rounding off Patrick's collection was this 15-inch reflector, with a mirror re-figured by George Hole. It was mounted on a Fullerscopes fork mount, housed in a rotating 'oil drum'-style observatory and was used mainly to study the Moon and planets.

▲ **Patrick lived at Farthings (a pun on 'Far Things') in Selsey from the late 1960s until his death in 2012**

▶ Russian space agency requested a copy to help it plan its uncrewed Lunik missions.

Patrick's life became even busier in 1965 when he took a part-time position as director of a new planetarium being set up in Armagh, Northern Ireland. He made a big impact there, overseeing the completion of the planetarium and turning it into one of the most popular tourist attractions in the area. He left Ireland in 1968, and he and his mother bought a thatched house in Selsey, West Sussex. It was a big investment, but the Apollo 11 Moon mission the following year helped secure the household finances. Within a month of its landing on the lunar surface, Patrick's *Moon Flight Atlas* had sold 800,000 copies.

Patrick was a constant presence on television during the years of the Apollo missions, covering them live with fellow presenter James Burke. The hours were long and demanding – on the night of the Apollo 11 landing, he broadcast continuously for over 10 hours. He covered the final mission, Apollo 17 – a spectacular night-time launch – from Cape Canaveral, having been studio-bound until then.

The cancellation of Apollo was far from the end of Patrick's forays into live broadcasting. In the 1970s and 1980s, a series of unmanned NASA probes began exploring the Solar System, and he revelled in a stream of surprises, such as the lifeless surface of Mars revealed by the Viking landings in 1976, and the glorious images from the Voyager missions to the outer planets.

Aside from broadcasting, he made many other contributions to astronomy. In the 1950s, he was involved in research that attempted, unsuccessfully, to reveal a link between radio emissions and spots on Jupiter's surface as they rotated into view. And in 1971, during the Mariner 9 mission NASA asked him to visit Johannesburg to observe dust storms on Mars to help them select areas to photograph. His activities helped amateur astronomy too. In 1995, he compiled a list of bright, deep-sky objects (clusters, galaxies and nebulae) to complement the Messier Catalogue, put together over 200 years earlier. This list, the

▲ A huge cricket fan, Patrick was taking 100 wickets a season in local matches well into his seventies

Caldwell Catalogue, became extremely popular (see our feature on **page 66**).

## Inspiring a love of space

Above all, he was tireless in promoting astronomy to the public – anyone who showed an interest was given the warmest encouragement. Many professional astronomers owe their careers to the inspiration they received from a tour of his telescopes and a cup of tea with him. Members of the public would merely have to write to him to be invited to his home, Farthings, for the day.

Patrick's love of humour was apparent throughout much of his work and he was certainly never afraid to laugh at himself. He performed TV comedy alongside the likes of Michael Bentine, Morecambe and Wise, and Jon Culshaw, and once joined the Flat Earth Society as a joke. Although best-known for his TV work, Patrick also gave many public lectures, including three nationwide tours of provincial theatres in the 1990s.

Patrick with the BAFTA presented to him by Buzz Aldrin for services to television

▲ Mishaps were far from unknown on live television. In 1961, Patrick and his friend George Hole attempted to broadcast live images of Jupiter but were continually – and somewhat comically – thwarted by banks of clouds

Patrick's career as a writer extended to the news media, as he contributed countless articles to newspapers and magazines. At various times, he was an editor and consultant for a number of astronomy magazines in the UK, giving his full support to *BBC Sky at Night Magazine* when it launched in 2005, becoming the magazine's Editor Emeritus and writing two columns in each issue until he died in December 2012. He regularly received recognition for his work, accumulating an impressive array of honours including an honorary fellowship of the Royal Society, a BAFTA, an OBE, a CBE, a knighthood and numerous honorary doctorates.

On Patrick's death in 2012, Britain lost a national treasure; a larger-than-life character, yet also a man of deep compassion who was quick to make friends. For many decades he was the public voice of astronomy, raising awareness and helping countless amateur astronomers to pursue their hobby. Just as crucially, he inspired generations of professional astronomers and a multitude of writers and broadcasters to educate a fascinated public about its wonders.

**A version of this article appeared in *BBC Sky at Night Magazine*'s special issue *The Extraordinary Life of Sir Patrick Moore*, published in 2012**

Patrick Moore 100

# Take the Caldwell challenge

## Celebrate the life of Patrick Moore with 10 deep-sky objects from his own astronomical catalogue

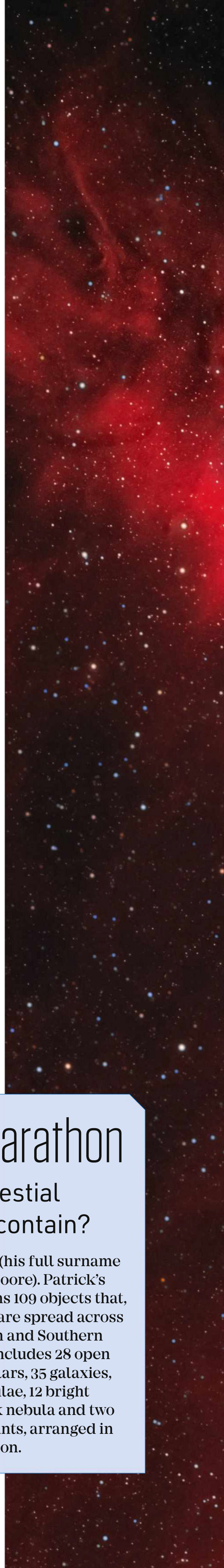
The early spring nights of March are ideal for discovery, something Patrick Moore, our late Editor Emeritus, was keen to encourage. To celebrate what would have been Patrick's 100th birthday, we've put together a special challenge based on his very own Caldwell Catalogue.

We're inviting you to take a tour of 10 of our favourite objects from his list, all of which are visible this month. Your task is to find them all in a single observing session. Some of the targets are quite popular, and you'll have seen them in our monthly deep-sky and binocular tours, while others are a little less well-known. Hopefully you'll be discovering some of these for the first time.

The minimum size telescope for this challenge is a 4-inch refractor: all of the objects are within reach of this size instrument under dark skies. Larger apertures will certainly help, of course, revealing hidden details that may otherwise elude you.

We suggest that you attempt the challenge near the third week of the month to avoid interference from the Moon's light. A couple of days either side of 21 March, starting at about 20:00 UT and finishing at about 22:30 UT, would be a good goal if the clouds play fair.

As it is spring, don't be caught out by a cold snap and be sure to wear suitable warm clothing and have some hot drinks on hand. Why not involve some friends and their telescopes in the challenge and make this a social occasion too? ▶



Patrick devised his list in 1995 in response to shortcomings in the Messier Catalogue

HOMER SYKES/ALAMY STOCK PHOTO, ROLF GEISSINGER/CCDGUIDE.COM

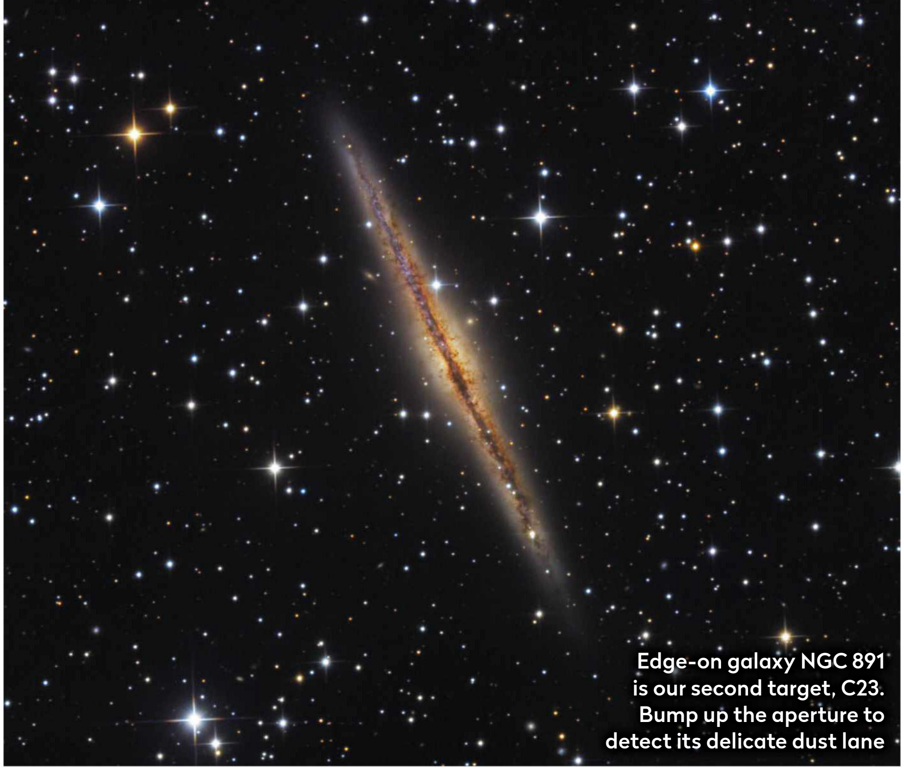
## The making of Moore's marathon

### Why did Patrick produce his own celestial catalogue, and what targets does it contain?

The Caldwell Catalogue came about because Patrick felt that the Messier Catalogue – a list of 110 objects originally created to tell comet hunters what to *avoid* – was somewhat incomplete. So he drew up a list of his favourite objects, all absent from Charles Messier's magnum opus. With the 'M' of Moore already taken, Patrick opted to use the 'C' of Caldwell for the objects in his list (his full surname being Caldwell-Moore). Patrick's catalogue contains 109 objects that, unlike Messier's, are spread across both the Northern and Southern Hemispheres. It includes 28 open clusters, 18 globulars, 35 galaxies, 13 planetary nebulae, 12 bright nebulae, one dark nebula and two supernova remnants, arranged in order of declination.

The magnificent Flaming Star Nebula or Caldwell 31, one of our top 10 picks from Patrick's Caldwell Catalogue

Patrick Moore 100



Edge-on galaxy NGC 891 is our second target, C23. Bump up the aperture to detect its delicate dust lane

Beautiful through binoculars and a sublime sight with a scope, the Double Cluster, C14

## 1. NGC 752

**Also designated: C28**
**RA 1h 56m 53s, dec. 37° 47′ 38″**

We start our challenge with a fine binocular object originally discovered by Caroline Herschel in 1783. Open cluster C28, also known as NGC 752, lies about one-third of the way between mag. +2.3 Almach (Gamma (γ) Andromedae) and the apex star in the constellation of Triangulum, mag. +3.4 Mothallah (Alpha (α) Trianguli). It can be easily found by sweeping between the two stars and, at almost two billion years old, this is one of the oldest star clusters known. Binoculars will show in the region of 30 widely scattered stars, although a rich-field telescope at low magnification is the best way to really enjoy this lovely object, revealing in excess of 60 individual member stars, more than a dozen of which are brighter than mag. +10.0.

## 2. NGC 891

**Also designated: C23**
**RA 2h 22m 36s, dec. 42° 21′ 00″**

Moving nearly 7° northeast now, your second object lies one-third of the way along a line joining the stars Almach and mag. +2.1 Algol (Beta (β) Persei). We're looking for mag. +9.9 edge-on galaxy NGC 891, and although it is visible in a 4-inch telescope, its low surface brightness means you may need to use averted vision. It is worth lingering here a little, as more and more detail will be revealed as your eye becomes accustomed to the view. If you can increase your aperture and up the magnification to around 120x, with careful scrutiny you should discern a slender dark dust lane bisecting the galaxy. This object was originally discovered by William Herschel in 1784 and it is believed to be over 30 million lightyears away from us.

▲ The Owl Cluster, C13 in Patrick's list, should be an easy hop from Ruchbah

MICHAEL BREITE/STEFAN HEUTZ/WOLFGANG RIES/CCDGUIDE.COM X 2, BERNHARD GOTTHARDT/CCDGUIDE.COM, BERNHARD HUBL/CCDGUIDE.COM, CHART BY PETE LAWRENCE

## 3. Double Cluster

**Also designated: C14, NGC 869 & NGC 884**
**RA 2h 19m 00s, dec. 57° 9′ 00″**

Continuing our journey into Perseus, your next target is a real treat: two objects for the price of one! NGC 869 and NGC 884 are popularly known as the Double Cluster today; in antiquity it was the Sword Handle, referencing the jewel-encrusted sword given to Perseus by Athena and Hermes to help him behead the Gorgon Medusa (the latter is represented by the star Algol). The individual clusters are a fine sight through binoculars and can be seen with the naked eye from a dark location. A binocular sweep between mag. +3.9 Tau (τ) Persei and mag. +2.7 Ruchbah (Delta (δ) Cassiopeiae) will easily find them. NGC 884, the more easterly of the two, contains numerous white-blue stars, whereas NGC 869 is dimmer and more compact.

## 4. The Owl Cluster

**Also designated: C13, NGC 457**
**RA 1h 19m 6s, dec. 58° 20′ 00″**

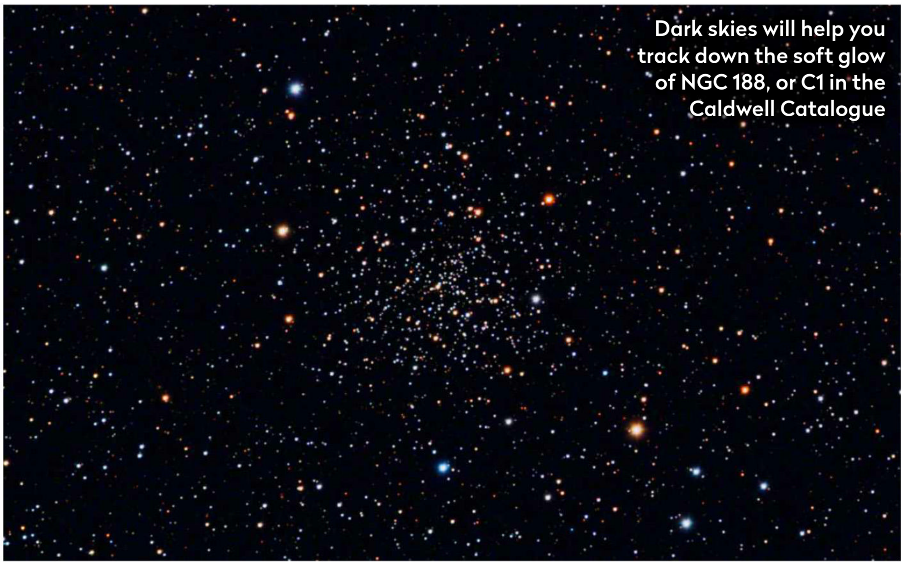
We leave Perseus and continue into Cassiopeia, a constellation named after a


queen who vainly boasted of her unrivalled beauty. There is real beauty here, though, with the aptly named Owl Cluster – although it is also sometimes referred to as the ET Cluster because its shape has been said to resemble the alien from the film of the same name. The brightest star visible in the cluster is one of the Owl's eyes, mag. +5.0 Phi (ϕ) Cassiopeiae. It lies 2° southwest of Ruchbah, so is quite easy to find. In truth, bright red Phi Cassiopeiae is not actually a member of the cluster at all, but a foreground star. All the same, it certainly adds to the view through binoculars or a small scope.

### 5. NGC 188

**Also designated: C1**
**RA 0h 47m 11s, dec. 85° 14' 38"**

Once you tick off this next object you'll be halfway through the challenge. Located just 4° to the south of the Pole Star, Polaris, open cluster NGC 188 is often ignored by observers with equatorial mounts as locating objects this close to the pole can be a bit fiddly. But what's an observing challenge without a bit of challenge? Unusually for an open cluster, this one comprises many older stars, more yellow than the hot, white, young stars that you might have expected. With a magnitude of +8.1, it's not a naked-eye object, but a 4-inch telescope at 30x magnification will reveal it as a stretched scattering of stars set against a brighter circular core. ▶


Dark skies will help you track down the soft glow of NGC 188, or C1 in the Caldwell Catalogue

Patrick Moore 100

▲ The lonely Intergalactic Wanderer, C25, at 275,000 lightyears away is a challenge

Larger scopes will reveal arms gleaming with new star formation in C7, the spiral galaxy NGC 2403

Big aperture and transparent skies will get the best from the Flaming Star Nebula, C31

## 6. NGC 2403

**Also designated: C7**
**RA 7h 36m 54s, dec. 65° 36′ 0″**

We are halfway through, so now is a good time to take a break and warm up with a hot drink as you prepare for the second stint. Our first object in the final run is spiral galaxy NGC 2403 in Camelopardalis. It has an appearance very similar to that of the Triangulum Galaxy, with numerous HII star-forming regions within its two layers of spiral arms. Shining at mag. +8.9, this is one of the brightest galaxies in the sky – but again, like the Triangulum Galaxy it is large and that brightness is spread out. NGC 2403 is somewhat isolated in sparsely populated Camelopardalis. You can find it just under 8° west of mag. +3.3 Muscida (Omicron (ο) Ursae Majoris). A 4-inch telescope will show an elongated hazy patch, but you will need a 12-inch telescope to view the spiral arms.

## 7. The Intergalactic Wanderer

**Also designated: C25, NGC 2419**
**RA 7h 38m 6s, dec. 38° 53′ 0″**

A quick hop southwards into Lynx will take us to a distant globular cluster known as the Intergalactic Wanderer, as it was originally believed to be located outside the gravitational influence of the Milky Way (something we now know to be untrue). Discovered by William Herschel in December 1788, this cluster is one the remotest globulars ever found, at a distance of around 275,000 lightyears. Look for it 7° to the north of mag. +1.6 Castor (Alpha (α) Geminorum). It's a difficult object in a 4-inch telescope, but a 10-inch or larger will reveal its condensed core and patchy halo.

## 8. NGC 2392

**Also designated: C39**
**RA 7h 29m 12s, dec. 20° 55′ 0″**

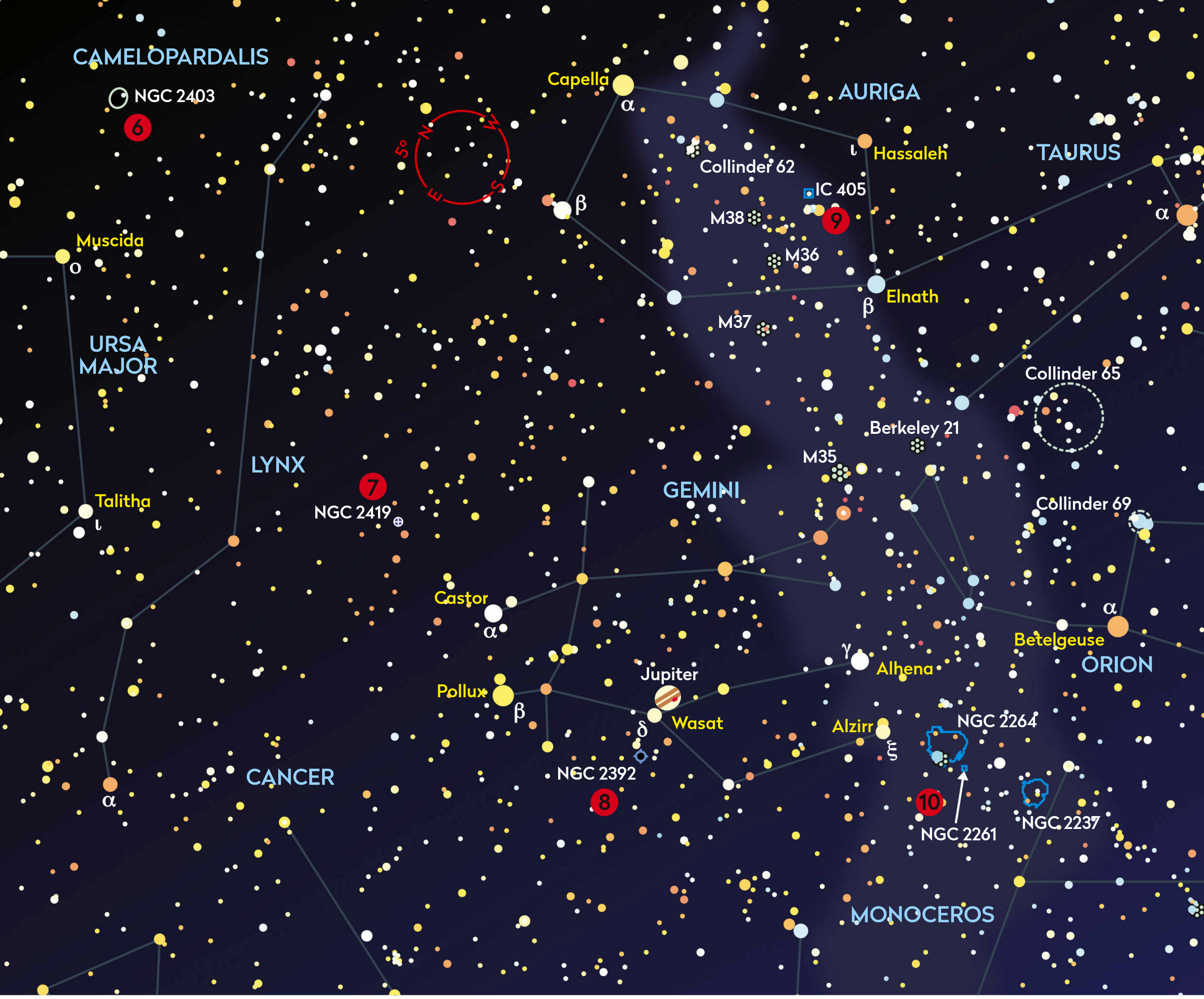
We continue our journey south into Gemini, sweeping past Castor and onwards to a point 2.4° southeast of mag. +3.5 Wasat (Delta (δ) Geminorum) to find a fascinating planetary nebula, NGC 2392. Although visible through a 4-inch telescope, with a diameter of only 48 arcseconds you'll need at least a 6-inch telescope to show the true shape of the nebula. A 10-inch or larger instrument will reveal a host of other delicate details, including two distinct shells – a bright inner mottled region with an outer faint halo, separated by a dark ring. The nebula's very distinctive appearance wasn't lost on William Herschel, who described it as "a very remarkable phenomenon" when he discovered it in 1787.

## 9. The Flaming Star Nebula

**Also designated: C31, IC 405**
**RA 5h 16m 12s, dec. 34° 16′ 0″**

Although our next object is an astrophotographer's dream, it is more challenging for observers. The Flaming Star Nebula lies 4.2° east-northeast of mag. +2.7 Hassaleh (Iota (ι) Aurigae) and is a delightful mix of both reflection and

BERNHARD HUBL/CCDGUIDE.COM X 2, FRANZ KLAUSER/CCDGUIDE.COM, WOLFGANG PROMPER/CCDGUIDE.COM, CHART BY PETE LAWRENCE




emission nebulosity. The star responsible for generating all the energy is HD 34078, which can be clearly seen at the heart of the nebula. However, this star is here by chance: it's just passing through on its long journey away from a cataclysmic interaction with the Trapezium stars in the Orion Nebula in the distant past. The roughly triangular shape of the nebula can be discerned through a 6-inch or larger telescope, but HD 34078 dominates the view. Try fitting a hydrogen-beta filter to your scope to tame the star.

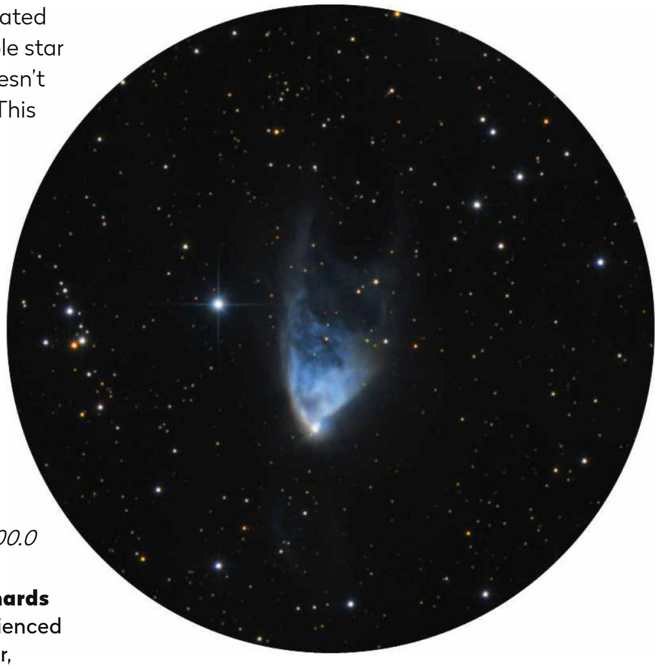
### 10. Hubble's Variable Nebula

**Also designated: C46, NGC 2261**
**RA 6h 39m 12s, dec. 8° 44′ 0″**

Congratulations, you have reached the final object! This is the enigmatic comet-shaped nebula NGC 2261, also known as Hubble's Variable Nebula from a series of images captured by Edwin Hubble in January 1949. The nebula changes in brightness and to a lesser extent shape, and although it is illuminated at its head by the T Tauri variable star R Monocerotis, its variability doesn't exactly match that of the star. This unusual behaviour is caused by dust clouds orbiting close to the star, blocking its light and casting shadows across the nebula. Located 4.4° south-southwest of mag. +3.3 Alzirr (Xi (ξ) Geminorum), it is visible in a 4-inch telescope, though the nebula's curved wedge shape is more clearly revealed through an 8-inch telescope at around 120x magnification.

*RA/dec. positions correct for J2000.0*

**Steve Richards** is an experienced astronomer, astrophotographer and our expert Scope Doctor



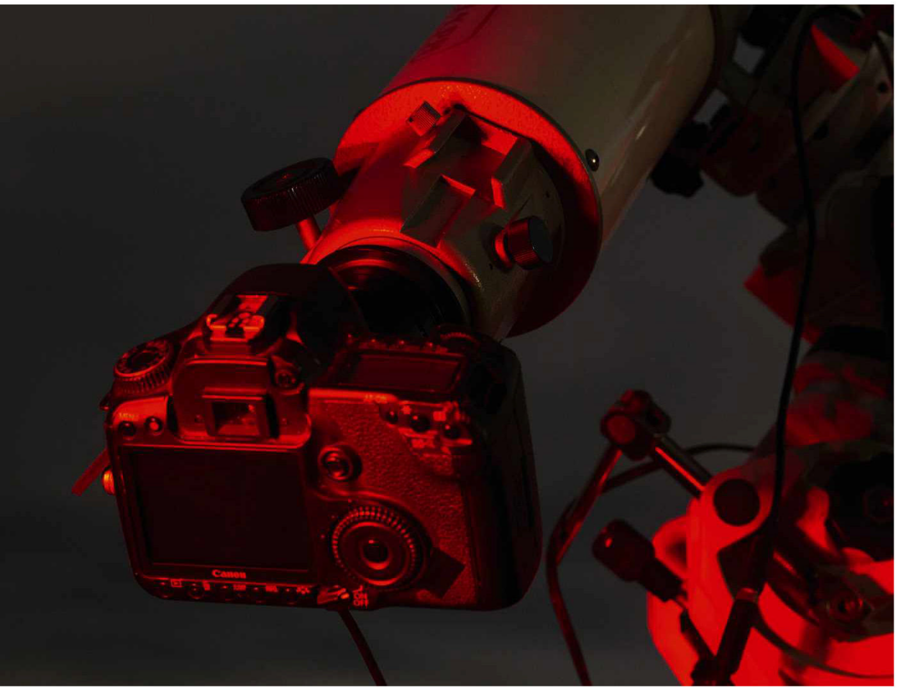
▲ Your final challenge is to locate the curious triangular-shaped nebulosity of Hubble's Variable Nebula, C46

The fundamentals of astronomy for beginners

# EXPLAINER

## Attaching a DSLR to a telescope – a simple guide

**Charlotte Daniels** on how use a telescope like a camera lens for close-ups of the stars



▲ **Above left: Attaching your DSLR to a refractor opens up a whole world of new imaging possibilities**

**Above right: A remote shutter release will help stop camera shake blurring your photos**

DSLR cameras are great for astrophotography. They're highly adaptable, and entry- and mid-level models are reasonably affordable thanks to an active secondhand market. And, as I'll explain, they're easy to attach to a telescope in place of the lens.

While a camera lens might allow widefield astrophotography, attaching a DSLR to a telescope lets you get close up to plenty of subjects, and will display them in a whole new light. The telescope's long focal length is the secret ingredient.

Furthermore, camera lenses are designed for daylight conditions rather than night skies. This means, among other things, a lens can distort astrophotos by introducing curved stars towards the edges of an image, or colour distortions so that stars show colour fringing.

Most telescopes are suitable for pairing with a DSLR. However, longer focal lengths can be tricky for beginners as they highlight tracking inaccuracies with the mount, such as an incorrect polar alignment.

ALL PICTURES: PETE LAWRENCE

Some reflecting telescopes will not achieve focus with a camera attached, so it is always best to check online forums and reviews to see whether the model is suitable for your DSLR.

Standard DSLRs are manufactured for use during the day, but their settings can be optimised for low-light and night-time conditions. Whether yours will make a good astro camera depends on a few key things: it should have a 'Bulb' setting that allows exposure times to be manually set, a live view function to help star focus, and the ISO setting should be adjustable.

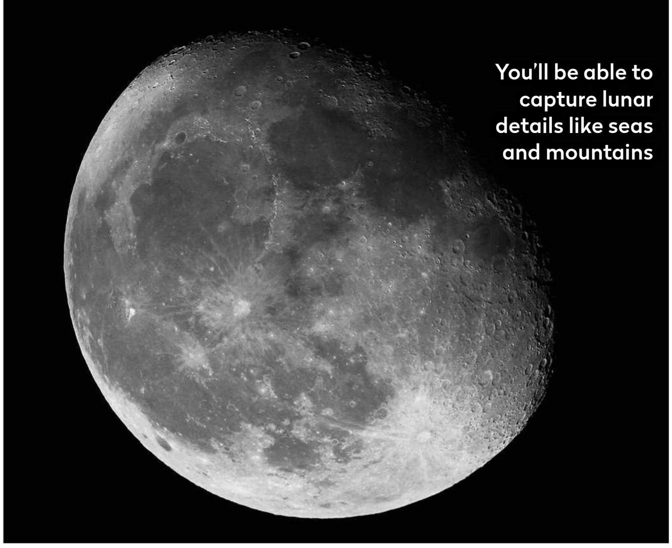
### Get focused

An intervalometer or remote shutter release is an indispensable piece of kit to have. This affordable accessory lets you fire off multiple exposures without joggling the camera, as well as programme exposure times once in Bulb mode. Keep this plugged into your DSLR at the start of an imaging session.

Once basic DSLR settings are understood, it's easy to use one to capture a range of astronomical objects with a telescope. We'll demonstrate with a Canon DSLR on the Orion Nebula, M42. Useful buttons on a Canon are the 'Q' button, which allows you to switch between settings, and the zoom buttons for focus. Most models have similar buttons and settings.

Before locating an object, focus your stars. Find a bright star such as Vega or Aldebaran and press the live view button. It should appear on the camera's

Objects like the Orion Nebula will be within reach once your DSLR is connected up



You'll be able to capture lunar details like seas and mountains

screen. If it doesn't, the camera is probably very out of focus, so adjust this. The star should grow or shrink accordingly, and we want it small and sharp. Use the zoom button to zoom in on the view on-screen and, once satisfied, zoom back out to return it to normal.

Now take a test image to make sure the stars are like pinpricks. Set the ISO to about 800 and shoot off a short exposure of around five seconds. Once the stars look good, it's time to find the Orion Nebula.

Once it's located, increase the exposure time. Select the Bulb setting and use your intervalometer to set the time to 20 seconds, which should be enough to show the nebula. Take a test image. Perhaps try increasing the ISO to 1600 and take another – does it look better or worse? Increase the exposure time to 30 seconds, and then a minute. The best ISO/exposure combination will depend on your camera, but once this is found you're ready to start your deep-sky imaging run.

DSLRs can also be used to image the Moon. For this, you want a low ISO setting (start at the lowest and work your way up) and fast exposure times to prevent over-exposed and blurry images. A camera's video capability helps, as the high frame rate will cut through Earth's atmosphere to produce sharper images.

If you're buying a telescope for DSLR astro imaging, you'll also need to consider the other equipment required. For one, telescopes do require a tracking mount – their longer focal lengths show a small section of the sky, so objects and stars move across the field of view quickly. Depending on the weight of the telescope and camera combined, you may get away with a lightweight, portable mount.

**Charlotte Daniels** is an amateur astronomer, astrophotographer and journalist

# Attaching your DSLR to a telescope

## With a few accessories you can swap your eyepieces for your camera

The two things you need to attach your DSLR are a 'T-ring' and a nosepiece. T-rings are manufacturer-specific, so make sure you get the right one for your DSLR. To an extent, the T-ring you require can also depend on the model of camera. For example, a Canon DSLR with a full-frame sensor will often take the same T-ring as one with a smaller APS-C sensor, but Canon mirrorless cameras have a different lens attachment and so need a mirrorless T-ring.

The next thing you need to do is measure the width of your telescope focuser, where an eyepiece would go. Most take either 1.25-inch or 2-inch barrels. We recommend, if possible, telescopes with at least a 2-inch as it helps reduce vignetting in your images. Once you've measured the diameter, you should acquire a 1.25- or 2-inch-to-T2 nosepiece.

To attach the camera to your telescope, first fit the nosepiece to your T-ring. The nosepiece is threaded, so will screw in. Then remove the front cap or lens from your DSLR camera body and attach the T-ring exactly as if you were attaching a camera lens. Finally, insert the free end of the nosepiece into your telescope focuser as you would an eyepiece and secure it by tightening the screw(s) located on the focuser. You're now ready to start imaging.


▲ With a manufacturer-specific T-ring locked on your camera body and threaded nosepiece, your DSLR will soon be imaging the stars

Practical astronomy projects for every level of expertise

# DIY ASTRONOMY

## Make a sky-measuring tool

Use household objects to build a simple device that gauges distances in the sky


The finished sky-measuring tool made using wooden sticks and lids

Whether it's a noctilucent cloud display, a constellation or an ice halo, being able to estimate how much sky an astronomical object covers and its apparent distance from, for example, the Sun or Moon is an essential skill. Beginners can find this challenging, and the difficulty is compounded by the fact that when objects are close to the horizon our brain perceives them as looking larger than when they are higher in the sky. If you have ever watched a full Moon rising or setting, you will be familiar with this phenomenon.

A well-known technique for measuring the sky involves stretching your arm out fully and using your hand in different positions. This works because the length of your arm is in proportion with the size of your hand. However, there are problems with this method. It isn't clear just how much you're supposed to stretch your hand, and some people have more flexible joints or proportionally larger hands than others. This can translate to a significant difference in measurement. It also relies on remembering how many degrees of sky each hand position represents.

In this project, we show you how to make a device from simple household items to measure the sky more consistently than with the hand method. These items are a fixed size and the device is held at a fixed distance from the eye, so it can easily be used by people of all ages and heights. While it's not going to give you arcminute accuracy, it will give consistent results if used correctly. And because each stick is labelled, there is no need to memorise anything.

**Mary McIntyre** is an astronomy educator and teacher of astrophotography

### Put a lid on it

We have used a coin and a selection of lids from commonly used containers around the house. With the scale we used, 0.8cm equates to 1° of sky, so the 5p coin covers 2°, the 4.5cm lid covers 3.5°, the 7.5cm coffee lid 9.5°, 10cm yoghurt lid 12.5° and the 20cm biscuit tin lid 25°. You can use any objects that you have around, but make sure that they fit in the spaces between the craft sticks. To calculate how many degrees of sky your own objects cover, measure (in centimetres) the diameter, or the width if it's square, then divide it by 0.8.

When using the device, stand or sit upright and try to keep your shoulders straight. Place the handle against the front of one shoulder and support the weight with your hand (see the inset picture, top left). Closing one eye, line the other eye up with the selected disc and the target to be measured – the Hyades, for example, measures 4° from Aldebaran on one side to Gamma Tauri on the other. Note the discs we used are circular, so make sure you are measuring the width across the widest part of the disc.

### What you'll need

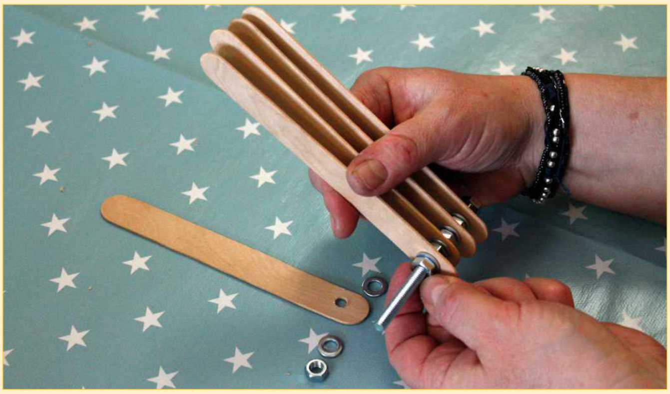
- ▶ Five wooden craft sticks. Ours measured 2cm x 15cm x 0.2cm
- ▶ A strip of wood 80cm x 3.5cm x 0.5cm, cut into two lengths: one 60cm long and the other 20cm long
- ▶ A bolt 8cm long x 8mm diameter, with eight corresponding nuts and 12 washers
- ▶ Four bolts 2cm long x 6mm diameter, with four corresponding nuts and washers
- ▶ An L-shaped bracket. Ours measured 5cm x 5cm and had pre-drilled 8mm diameter holes
- ▶ A selection of different-sized round or square flat objects. We used a 5p coin and lids from a 4.5cm jam jar, 7.5cm coffee tin, 10cm yogurt pot and a 20cm biscuit tin

ALL PICTURES: MARY MCINTYRE

# Step by step

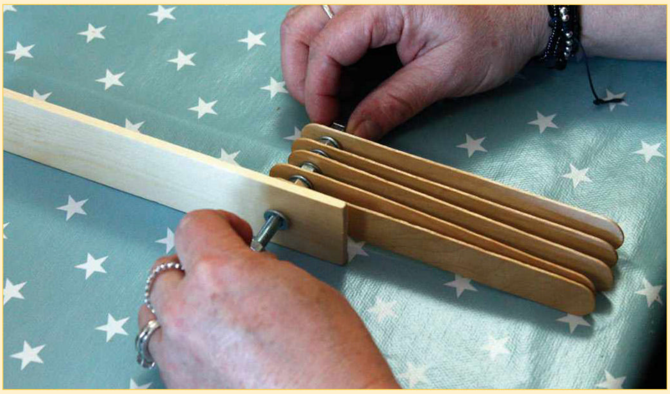
## Step 1

On each wooden stick make a mark in the centre, 1.5cm from one end. Drill 8mm diameter holes into each, where you've marked. The sticks can easily splinter with holes this big, so drill very slowly and place a wooden block underneath.



## Step 2

Screw a nut up to the top of the 8cm long bolt, add a washer, then slide the first stick onto the bolt. Add another washer, nut and stick, then repeat this pattern until all of the sticks are on the bolt. Each of the sticks should have a washer either side of it.

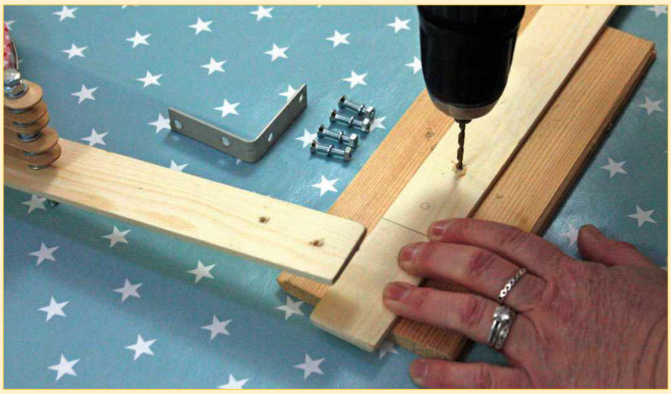


## Step 3

Take the 20cm long piece of wood and drill an 8mm diameter hole in the centre, 4cm from the end. Add this piece onto the bolt, making sure to sandwich it between two washers. Add two final nuts; ideally the last one would be a locking nut.

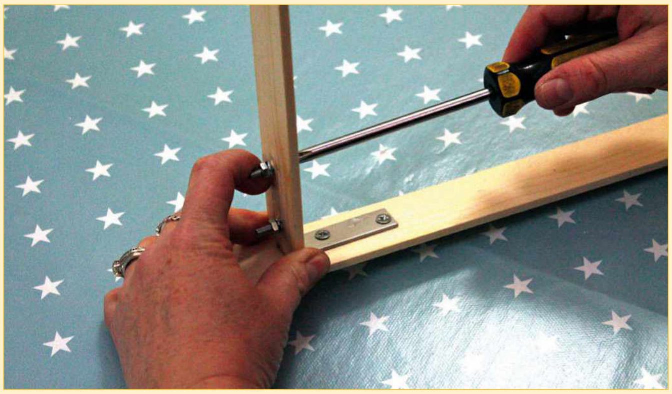
## Step 4

In ascending size order, glue each of your objects onto the wooden sticks using hot glue. We painted the edge of the clear yogurt lid white to help with visibility. Label each stick with the degrees of sky that each object covers.



## Step 5

Place the L-shaped bracket in the centre of the 60cm length of wood, 7cm from the end, and mark where the holes lie. Then place the 20cm piece of wood at right angles, agains the bracket, and mark the holes. Drill 6mm diameter holes into each mark.



## Step 6

Bolt the bracket in place, being sure to add a washer between the nut and the wood. Finally, with a spanner tighten the nuts that are between the craft sticks so that each stick has tension but is moveable. Your sky measuring device is now ready to use.

Take the perfect astrophoto with our step-by-step guide

# ASTROPHOTOGRAPHY CAPTURE

## Imaging the Moon – a beginner's guide

We walk you through how to get lovely lunar images, even with basic equipment

The Moon is a great target for photography, whatever your level of experience. Being bright and having a tangible size in the sky, it doesn't call for specialised or expensive equipment.

Although it's bright enough to photograph with a smartphone, the Moon may cause disappointment because, despite how it looks to your eye, it's actually pretty small. When fuller phases of the Moon are seen rising or setting, its proximity to the horizon makes it appear huge, an effect known as the Moon illusion. Try taking a photo of a Moon like this and you'll see just how small it really is.

A bright, fuller-phase Moon against a dark sky may also cause exposure issues. Attempting to capture the Moon against a foreground horizon, an automatic camera typically either favours the Moon, losing the foreground, or else the foreground, over-exposing the Moon.

One way around this is to try to catch the larger gibbous phases of the Moon during daylight conditions. The waxing gibbous phases can be seen in daylight in the afternoon to evening period before sunset, while the waning gibbous Moon appears in the morning sky after sunrise.

### Shoot for crescents

The waxing and waning crescent phases are even better as these can be caught under twilight conditions either after sunset or before sunrise respectively. Being less bright than a full Moon, a humble smartphone can often capture the shape of these beautiful crescents well.

More detail is gained by zooming into the Moon's disc. Here it pays to know your phone's spec. Typical phone cameras have optical and digital zoom

▲ **There are many ways to get great images of the Moon with basic kit, including simply pointing your smartphone camera down an eyepiece, as was the case here**

**Pete Lawrence** is an expert astro-imager and a presenter on *The Sky at Night*

ALL PICTURES: PETE LAWRENCE

capabilities. Optical zoom uses lenses to increase magnification; digital zoom uses software to stretch an optical result. Consequently, digital zoom doesn't really give you any more than the maximum optical zoom of your camera. You'd be better off using the maximum optical zoom setting then downloading and resizing the image yourself with photo-editing software.

Greater magnification can be obtained by coupling your phone to a telescope. The technique, known as afocal imaging, takes a bit of getting used to, but can produce surprisingly good results. Take a look at our guide opposite and try it for yourself.

Another way to show lunar details is to use a more sophisticated camera. A DSLR, MILC or equivalent is ideal for this because you can switch the lens out for something that will give you a better image scale. Basically, the longer the focal length, the larger the image scale. Use a lens beyond 200mm focal length and you'll start to see convincing detail in the Moon's disc. With a 1,000mm telephoto lens you'll see seas, mountain ranges and, of course, craters.

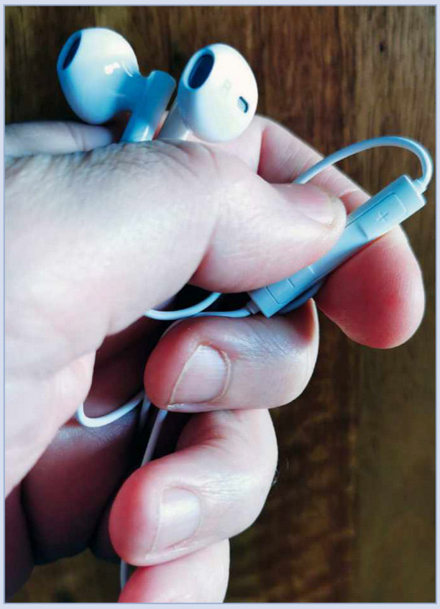
If you have a telescope, it's possible to couple your camera directly to the eyepiece holder to use the telescope as the telephoto lens. All you need is to use an adaptor ring specific to your camera make and model that has a T-thread, into which you can screw a nosepiece (**see page 72** for more on this technique).

Readily available from telescope stockists, these inexpensive adaptors will open up all sorts of photographic adventures for you.

**Equipment:** Smartphone, telescope

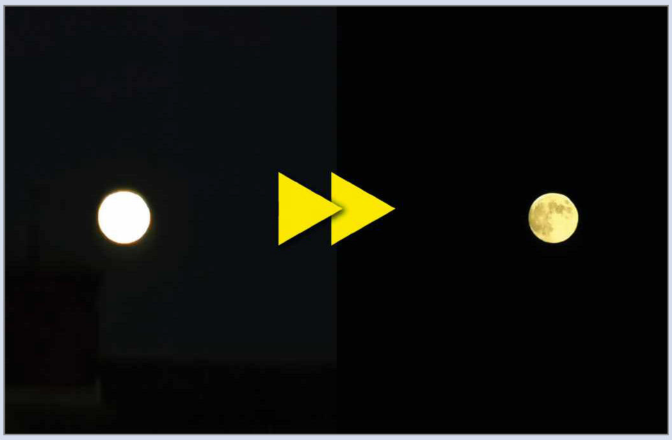
**Send your images to:**
**gallery@skyatnightmagazine.com**

# Step by step



### STEP 1

Check the maximum optical zoom of your phone. Googling its make and model should tell you this. On a night when the Moon is present, point the camera at it and let it make automatic exposure adjustments. Press the shutter button. If you have some, wired headphones with volume controls may work as a remote shutter release, the volume control activating the shutter.



### STEP 2

If your camera over-exposes the Moon into a bright blob of light, see if it offers a pro mode where you can control the settings. If so, hold the camera to the Moon so auto-exposure settings are made, then switch to pro mode, which should retain those settings. Reduce the ISO or exposure so the Moon's disc isn't over-exposed.

### STEP 3

To retain foreground detail as well as the Moon, the easiest way is to photograph the Moon when the sky is still bright and the foreground illuminated. This can be done with gibbous and full Moons during the day. Alternatively, crescent Moons will appear in the evening or morning twilight, after sunset or before sunrise.

### STEP 4

For more detail, consider pointing your phone's camera down a telescope's eyepiece. The telescope needs to be pointing at the Moon and properly focused. It helps if the mount is driven, to avoid the Moon drifting out of view. If you wear glasses or contact lenses to correct your vision, they need to be in place.

### STEP 5

Bring the phone close to the eyepiece, keeping the bright light emanating from the eyepiece in view. When as close as possible, make a final adjustment to the position of the phone so the Moon's image pops into view. Carefully press the button to take the shot. The headphone trick mentioned in step 1 is very helpful here.

### STEP 6

If you fail the first time, keep trying. It takes a while to get it right. This technique is known as afocal imaging and works with other bright objects too. If you like taking photos this way, consider buying a mount to attach your phone to your telescope. They can be bought at relatively little cost, but they make holding the phone in position a great deal easier!

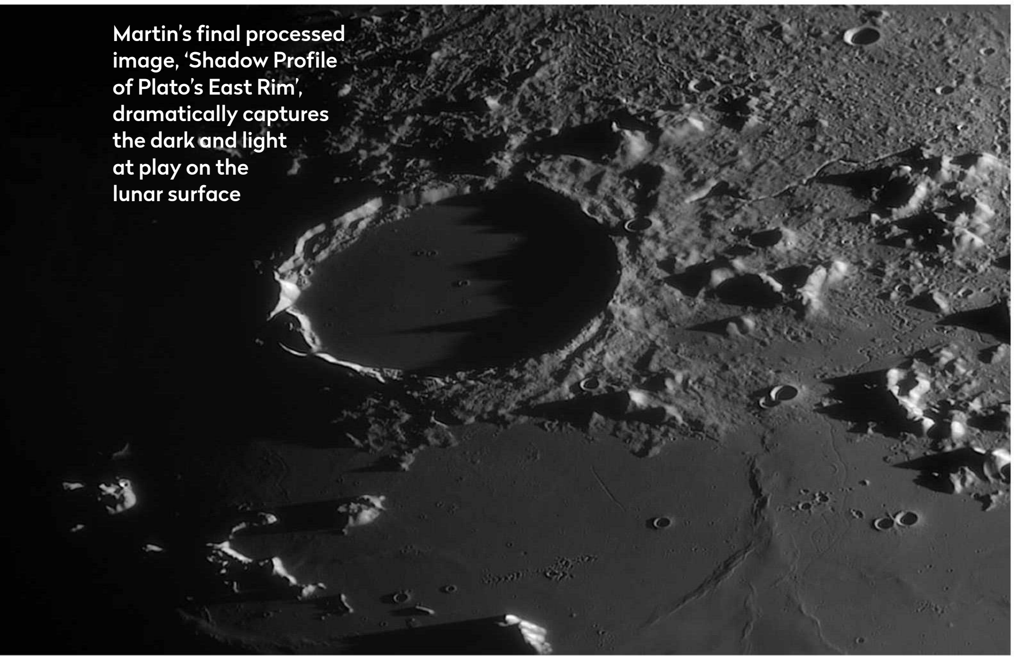
Expert processing tips to enhance your astrophotos

# ASTROPHOTOGRAPHY PROCESSING

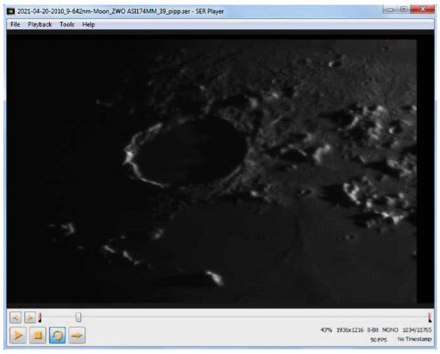
## Bringing out the shadow profile of Plato's east rim

### Tips to boost the impact of your lunar crater images

**Astronomy Photographer of the Year**
Advice from the 2022 winner in the 'Our Moon' category



**Martin's final processed image, 'Shadow Profile of Plato's East Rim', dramatically captures the dark and light at play on the lunar surface**



**▲ Screenshot 1: A single unprocessed frame from Martin's monochrome lunar video**

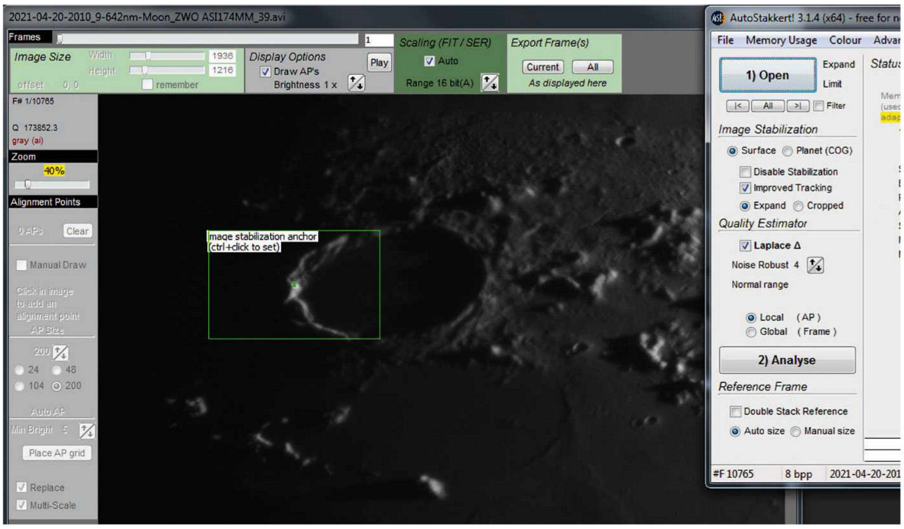
My image of the Plato region of the Moon was chosen as the overall winner in the 'Our Moon' category of the 2022 Astronomy Photographer of the Year competition, for which I felt very fortunate. The image relied on three key aspects for its strong impact: low Sun angle, favourable seeing and good composition. The Sun was rising over this particular area of the Moon when I took my image. This meant the jagged shadow from the crater's east rim was dramatically cast nearly halfway across the smooth lava-filled base of Plato. This represented a shadow length of nearly 72 kilometres (45 miles)!

The low Sun was also important in highlighting surface detail in the surrounding region, especially the mountain peaks and narrow rilles in the upper right-hand side of the image, adding to the strong texture there. The low Sun also revealed the gentle undulations in the lava plains in the smoother lower part of the image, and created the contrasting full darkness on the left side, where that part of the Moon was still in night.

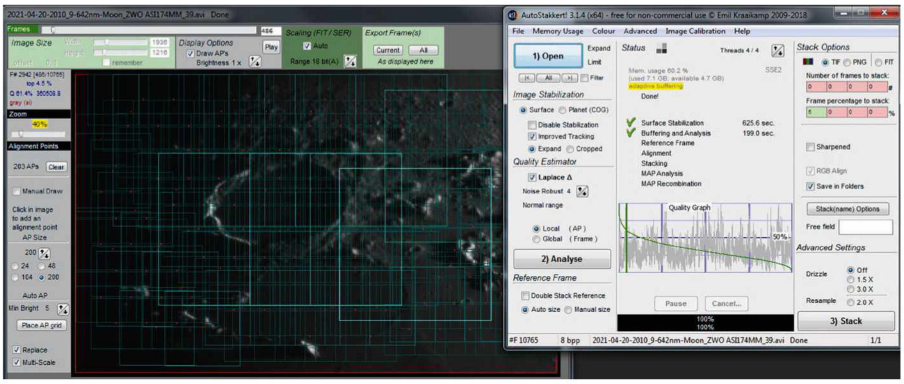
The photograph was taken on a night of very good seeing in April 2021 when the Moon was 60° high to the south. I used my 444mm Dobsonian telescope mounted on a home-built driven equatorial platform, combined with a ZWO ASI174MM mono digital video camera (recommended for lunar and solar captures due to its high speed and large chip size). I also chose a Barlow lens so the telescope was operating at f/29 – giving a magnification that nicely matched the scope's maximum resolution to the large pixels of the camera. This camera captured 10,800 individual images over a period of several minutes, with an exposure time of 29 microseconds per frame. I used a 642nm red filter in front of the camera to further improve the steadiness of the image.

## Out of the shadows

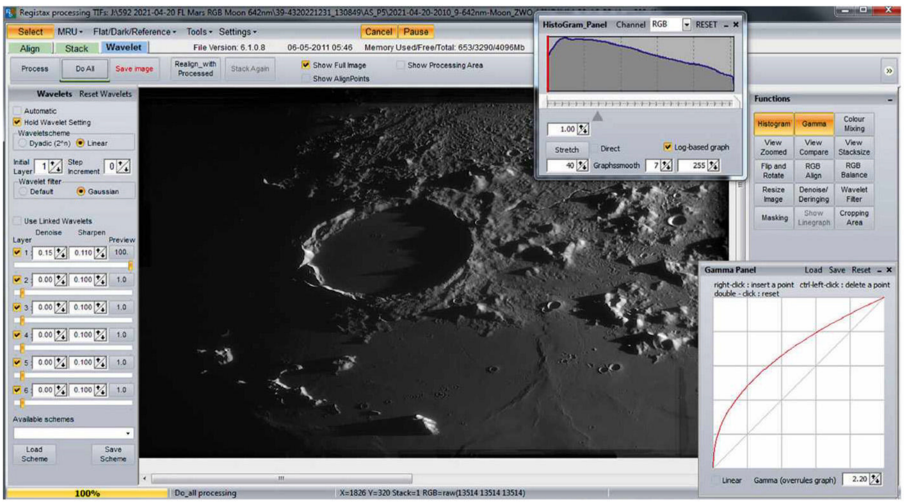
The five-minute video was processed in AutoStakkert! using the 'Surface' mode generally recommended for lunar and solar work. 'Surface' mode requires picking an obvious anchor feature first – which just had to be Plato. This anchor location was selected by holding down the Ctrl key and clicking on the crater, before then hitting the 'Analyse' button (see Screenshot 2).



▲ **Screenshot 2: In AutoStakkert!, Plato was chosen as the image stabilisation anchor point**



▲ **Screenshot 3: The whole image was divided into 203 separate alignment areas before AutoStakkert! stacked and aligned the best five per cent of the frames**



▲ **Screenshot 4: The stacked image was imported into RegiStax for sharpening, contrast adjustments and denoising. Final processing tweaks were done with PaintShop Pro**

Once the image had been analysed, the best five per cent of the total frames were selected to be stacked and an AP (alignment point) size of 200 was chosen with automatic placement. This placement divided the scene into 203 separate alignment areas; I picked a low minimum brightness of five, so that alignment areas were allocated even in the dimmest areas of the image (see screenshot 3).

Once I had clicked on the 'Stack' button and AutoStakkert! had done its work, quality-sorting and aligning the best frames, the final stacked image was imported into RegiStax for sharpening and contrast adjustment, as shown in screenshot 4. A low level of sharpening of 0.11 in RegiStax was applied at 100 per cent in just the first layer, using the Gaussian mode. I also added a low level of denoise (0.15) to smooth out any noise; not much was required because of the relatively long accumulated exposure duration of 15 seconds (five per cent of five minutes). As the seeing was so good, only a small level of sharpening was needed to pull out the fine detail, and this really helped to reduce the severity of any diffraction-related ringing artefacts seen around any bright edges and crater rims. It is this lack of obvious ringing artefacts around sharp features and cast against the dark shadows that separates the best lunar images from those that are not quite so good.

In RegiStax the darker areas were darkened with a bottom-end histogram stretch and the overall contrast actually reduced by increasing the gamma setting to 2.2, as shown in screenshot 4. This improved the overall look of the image, accentuating the shadow of the rim inside the crater of Plato which dominated the middle of the image.

Final processing took place in PaintShop Pro. This involved a further slight reduction in contrast, followed by cropping the edges of the image to make the most pleasing, natural and detailed overall composition, as shown in the final image on the page opposite.

## 3 QUICK TIPS

**1.** For lunar imaging at high magnification, pick the best nights with the steadiest skies and image the Moon high up in the sky.

**2.** If the seeing is not so good, image larger areas at lower magnification.

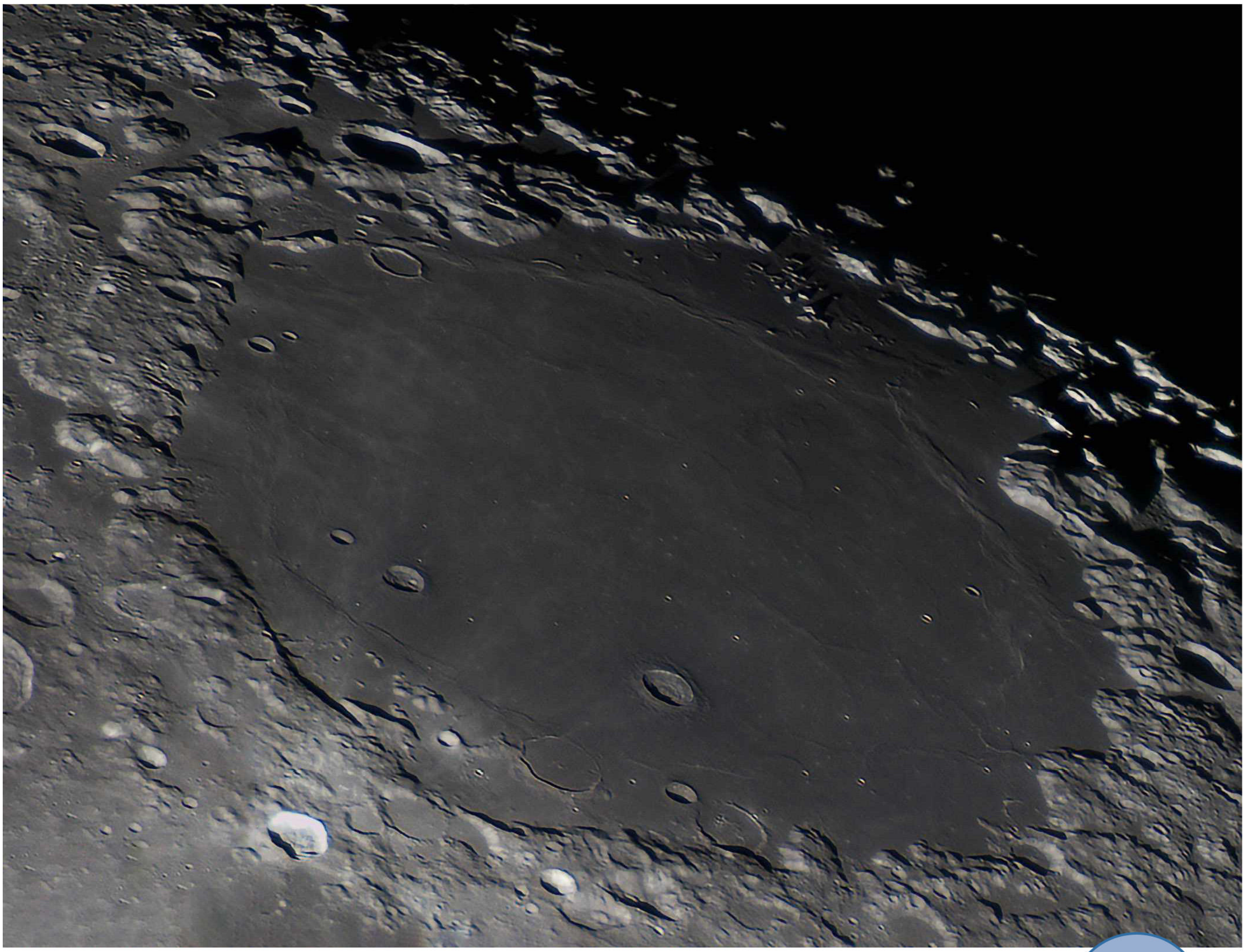
**3.** Don't over-process as diffraction effects surrounding high-contrast features will become obvious, spoiling the result.

**Martin Lewis** is an expert astronomer and planetary imager

Your best photos submitted to the magazine this month

# ASTROPHOTOGRAPHY GALLERY

More **ONLINE**
**A gallery containing these and more of your images**



## △ Mare Crisium

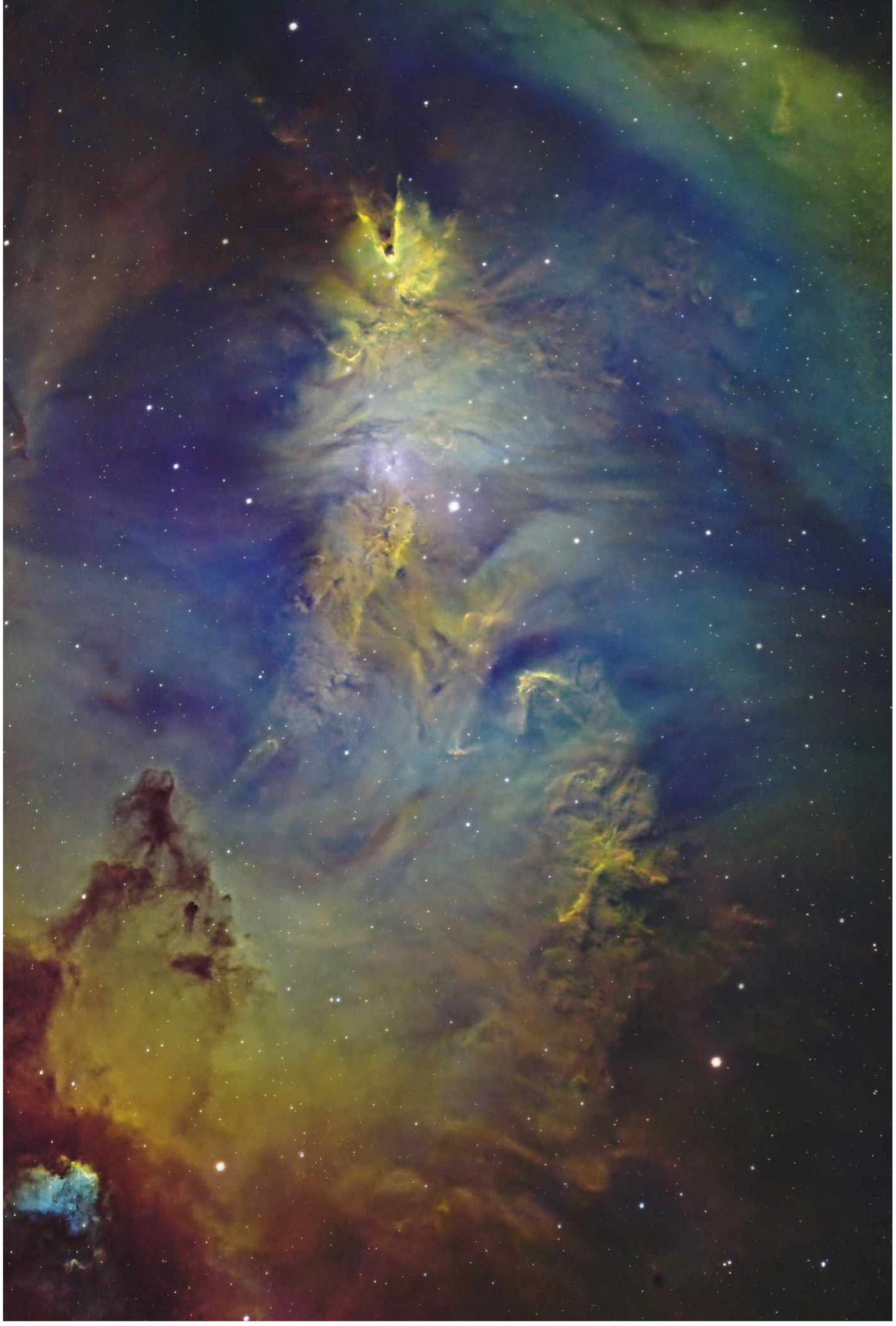
**PHOTO OF THE MONTH**

**Kevin Earp, Willington, Bedfordshire, 10 December 2022**

**Kevin says:** "I've always loved the Moon. The richness of features, especially when near the terminator, change over the span of only a few minutes, and are delightful to observe. At lunar sunset, Mare Crisium ('Sea of Crises') is fascinating, with delicate wrinkle ridges around the edges of the 'sea', isolated mountain peaks, and a range of craters contrasting with the smooth maria floor."

**Equipment**: ZWO ASI224MC Pro camera, Celestron C11 Schmidt-Cassegrain, Sky-Watcher NEQ6 Pro mount
**Exposure:** Mosaic of 9x 1,000-frame 15" AVI videos, 65fps, best 150 stacked from each
**Software:** FireCapture, AutoStakkert!, RegiStax, Photoshop

**Kevin's top tips:** "The camera's small field of view needed a mosaic to capture this view, with at least 25 per cent overlap between panels. To improve resolution, I used 'lucky imaging' – taking AVI videos and stacking the best frames. Capturing short videos helps avoid changes in illumination. Photoshop's Photomerge is excellent for making a smooth mosaic, followed by RegiStax's wavelet sharpening."



## △ Mars at opposition

**Robert Smith, Stevenage, Hertfordshire, 7 December 2022**

**Robert says:** "Mars won't be this close again until 2033. The volcano Olympus Mons is clearly visible as a bump on the surface just north of centre."

**Equipment:** ZWO ASI178MC camera, Celestron 9.25-inch Schmidt-Cassegrain, Celestron Advanced VX mount
**Exposure:** 15ms, gain 197, best 5,000 frames
**Software:** AutoStakkert!, RegiStax, GIMP

## ◁ The Cone and Christmas Tree Nebulae

**Peter Briggs, Cranborne Chase International Dark Sky Reserve, Wiltshire, 10–13 December 2022**

**Peter says:** "This season I decided to concentrate on narrow-band imagery. Unfortunately, our poor weather only allowed me three nights, but I think it came out well."

**Equipment:** ZWO ASI294MM Pro camera, William Optics Zenithstar 73 refractor, Sky-Watcher EQ5 Pro mount **Exposure:** 9h 59'
**Software:** APT, PixInsight, Affinity Photo

## NGC 1365, The Great Barred Spiral Galaxy ▷

**Fernando Oliveira de Menezes, Munhoz, Brazil, 1 August–24 October 2022**

**Fernando says:** "I've always wanted to photograph this galaxy. I hope to acquire a colour camera soon just for capturing galaxies and clusters, as they're my favourite things to image."

**Equipment:** ZWO ASI6200MC camera, Sky-Watcher Esprit 150ED refractor, iOptron CEM120 mount
**Exposure:** 193x 300"
**Software:** SG Pro, PixInsight, Photoshop

## △ Lunar solstice

**Simone Lochi, Oristano, Sardinia, 21 December 2022**

**Simone says:** "I was lucky enough to spend the night of the winter solstice filming molecular clouds in Taurus. This meant I was awake to see a spectacular moonrise, as the Moon rose just before the Sun from the same point on the horizon, so it looked like a real lunar solstice!"

**Equipment:** Canon 1100D DSLR camera, Canon EF-S 18–55mm lens, K&F Concept tripod
**Exposure:** ISO 3200, f/3.5, 8"
**Software:** Adobe Camera Raw, Photoshop

## ◁ M51, The Whirlpool Galaxy

**Paul Humberstone, Llandudno, Wales, 20–23 March 2022**

**Paul says:** "Messier 51 has always been one of my favourite deep-sky objects to observe through an eyepiece or to image. In late March 2022, I took advantage of the (mostly) clear skies to capture this graceful, spiral galaxy and its smaller companion. I used a focal reducer and UV/IR cut filter to get the final shot."

**Equipment:** ZWO ASI294MC Pro camera, Celestron 8-inch EdgeHD aplanatic Schmidt-Cassegrain, Sky-Watcher EQ6-R Pro mount
**Exposure:** 10h **Software:** PixInsight

## ▽ The Andromeda Galaxy

**Steve Young, Liphook, Hampshire, 20 December 2022**

**Steve says:** "Since starting astrophotography a few years ago, I've used Andromeda as a reference target to track my progress. My first attempts were little more than a smudge! With a few years of experience under my belt, I tried again in late December. This latest attempt used just over two hours of data, lots of calibration frames, and was processed using PixInsight."

**Equipment:** ZWO ASI2600MC Pro camera, Askar FRA400 refractor, Celestron CGX mount **Exposure:** 45x 180" **Software:** PixInsight

## △ Comet C/2022 E3 ZTF

**John Chumack, Yellow Springs, Ohio, USA, 29 December 2022**

**John says:** "The comet was shining at mag. +8.2 in the constellation Corona Borealis. You can see the bright nucleus, the nice green coma, the (brown) dust tail, and also the faint ion tail going off to the right, as well as some faint galaxies in the background and the 7th-magnitude star HIP 77721 in the lower right. I only got 24 minutes of data before the clouds killed it for me."

**Equipment:** ZWO ASI294MC camera, TPO 12-inch f/4 Imaging Newtonian, Software Bisque Paramount ME mount **Exposure:** 12x 2' **Software:** DeepSkyStacker, Nebulosity, PixInsight

## ENTER TO WIN A PRIZE. HERE'S HOW

**Whether you're a seasoned astrophotographer or a beginner just starting out, we'd love to see your images. Send them to us at www.skyatnightmagazine.com/send-us-your-astrophotos**

The best in equipment, accessories and books each month

# REVIEWS

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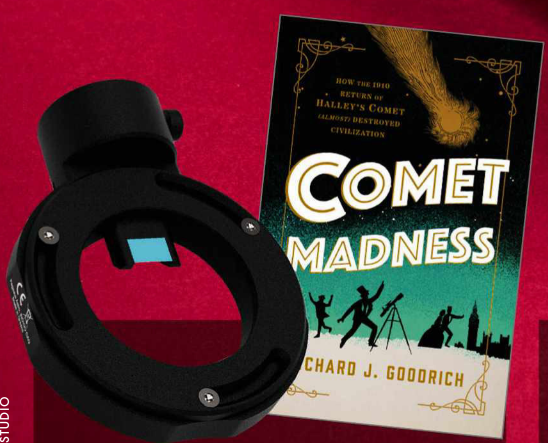
**86** QHY533C on test: why the CMOS with the square sensor will please beginners and buffs alike

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## HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good ★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

# FIRST LIGHT

# QHYCCD QHY533C colour camera

It may be entry-level, but this cooled CMOS is loaded with leading-edge features

WORDS: CHRIS GRIMMER

## VITAL STATS

- **Price** £989
- **Sensor** Sony IMX533 colour
- **Sensor size** 1 inch
- **Resolution** 9MP, 3,008 x 3,028 pixels
- **Exposure range** 30ms to 3,600 seconds
- **Connectivity** USB 3.0, CFW port, power
- **Size** 9 x 9 x 10.6cm
- **Weight** 845g
- **Extras** Mains power supply, USB 3.0 cable, adaptor kit
- **Supplier** Modern Astronomy
- **Tel** 020 8763 9953
- **www.**modern astronomy.com

With the continued improvements we're seeing with CMOS sensors for astrophotography, we were excited to take a look at QHY's recent offering, the 533C active-cooled colour camera. The QHY533 comes with either a mono (533M) sensor or with the one we are testing, the 15.97mm Sony IMX533 colour (533C) sensor. These latest Sony sensors offer superb sensitivity and low noise while also eliminating all amp glow, a common issue for CMOS cameras.

QHYCCD pitches the 533 series as beginner or entry-level cameras, and with a 1-inch square sensor this is one of the smaller-chip CMOS cameras it produces for deep-sky imaging. At 9MP, the 533 may seem small compared to some of its competitors on the market, but don't let that deceive you: the images produced from a 9MP camera will still be printable in formats larger than A3 size. Moreover, megapixels and resolution are not the only considerations, and this camera outperforms on read noise and dynamic range.

## Square sensor

Unlike nearly all other daytime or astrophotography cameras, the QHY533 has a square sensor. For daytime photography this may be troublesome, but night-sky imagers tend to find it allows us to easily frame objects. CMOS sensors also come into their own with shorter exposures, so will be more forgiving when used with lighter or portable mounts, as tracking accuracy is not so critical. Despite being pitched as a beginner camera, the housing and build of the QHY533C easily matches that of QHYCCD's high-end models and, with the significant addition of set point cooling, promises to deliver a lot of camera for the money.

Unboxing the camera, we found it to be made of solid aluminium and felt well-made. At 10.6cm long and 9cm wide, the weight of 845g will be easily handled by most telescope focusers without risk of slippage. Included in the box is a mains power supply, USB 3.0 cable and DSLR camera lens adaptor. Setting up was easy as QHYCCD has an all-in-one driver package available from its website. Once the drivers were installed, with the camera connected to our PC our capture software detected it and connected instantly. Loading the camera settings, it was nice to see some default settings available for gain and black level, depending on your target choice (deep-sky, planetary or solar). These will prove helpful for those new to deep-sky and CMOS imaging.

Leaving the setting on the default DSO (deep-sky object) mode, we set the cooler to –20°C and, once cooled, we ran a few dark frames to check for amp ▶


ALL PHOTOS: @THESHED/PHOTOSTUDIO

SCALE

## TEC cooling

The QHY533C is equipped with dual-stage set point thermoelectric cooling (TEC) down to –30°C. Not only that, but QHY has implemented new propriety technology to reduce electronic heat build-up in the camera, further reducing image noise, increasing the signal-to-noise ratio and improving image quality.


## Filter wheel connection

All QHYCCD's latest cameras can attach directly to its CFW filter wheel. Included on the rear of the camera is a direct connection port that allows control of the filter wheel via the camera, eliminating the need for a separate USB and power connection.


## Connectivity

Equipped with a high-speed USB 3.0 connection and a large 1GB image buffer, the QHY533C can seamlessly download captured images without the risk of any being lost in the transfer process. This also allows the camera to capture up to 27 frames per second in full-frame video mode for planetary imaging.

## Compact size

Coming in at 845g, the QHY533 is only slightly heavier than a standard DSLR so is well-suited to lighter-weight mounts. Using the provided camera tripod adaptor and DSLR lens adaptor, this camera is well within the weight limits of most portable or beginner tracker mounts and tripods.

## Adaptor kit

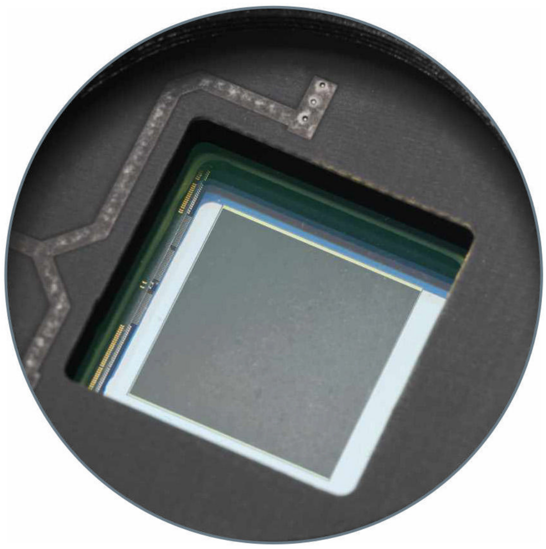
Included with the QHY533C is an adaptor kit that provides an additional 55mm back focus and M48 thread connection. This will allow a Nikon or Canon lens adaptor (bought separately) to be attached. At the same time, the QHY533C has female C-mount threads allowing direct mounting of C-mount lenses.

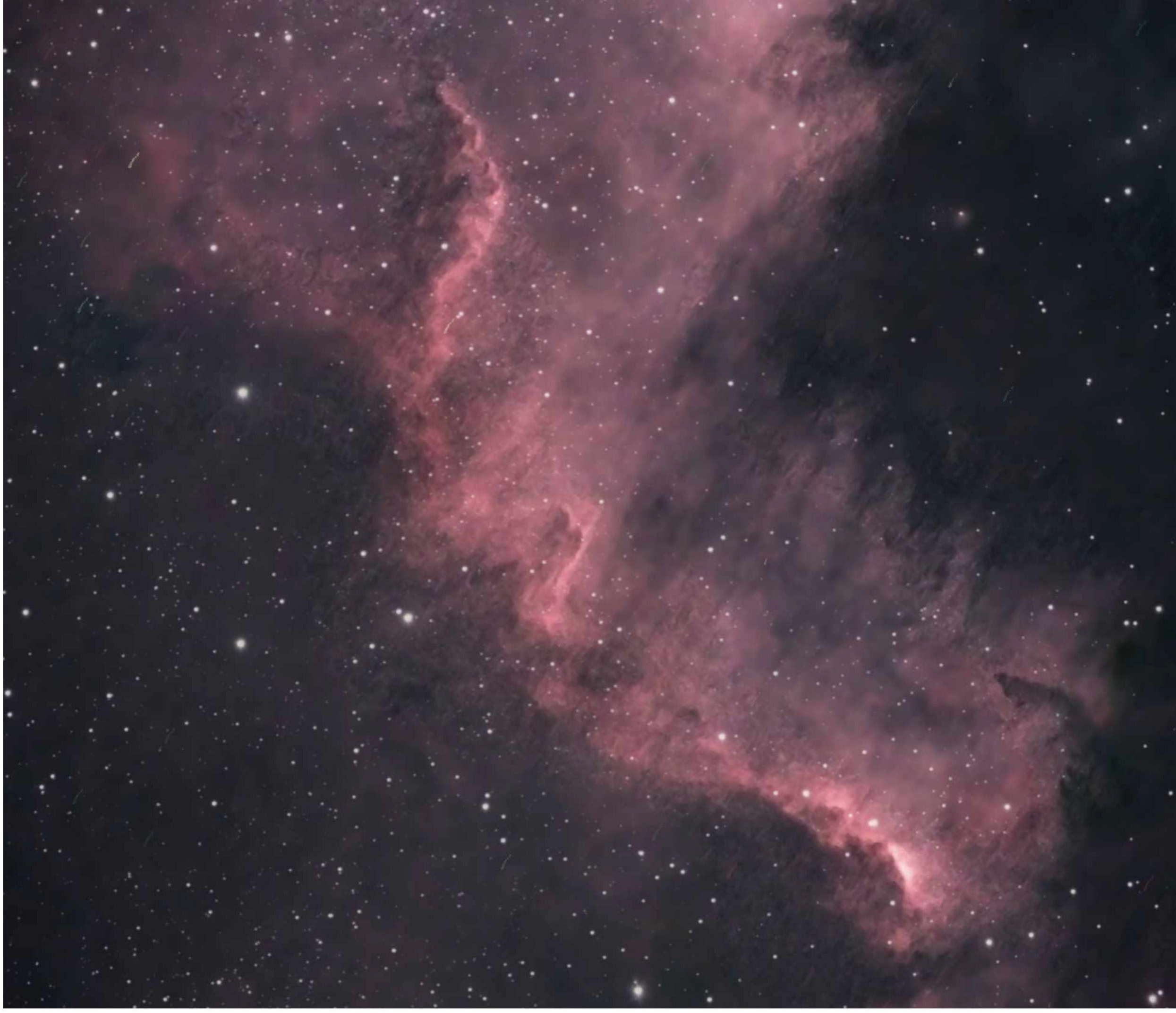
## Low noise, high sensitivity

The QHY533C is equipped with Sony's new generation of back-illuminated CMOS sensor. The 1-inch square sensor, comprising 3,008 x 3,028 3.76um pixels, is well-suited for medium to longer-length refractors (focal lengths of 500–1,000mm). 'Back-illuminated' means that all the embedded wiring within the chip is located behind the light-collecting elements, maximising the light-collecting power or QE (quantum efficiency).

The Sony IMX533 chip has very low noise while delivering high sensitivity and zero amp glow, even when pushing exposure times over five minutes. This combination makes calibration frames less critical and results in images that don't need so much cleaning up in post-processing, reducing the risk of overworking the data.

The manufacturer has also designed the camera to eliminate dew or frosting on the sensor by including replaceable desiccant tablets in the sensor chamber that remove all internal moisture. A heating element also protects the optical window from external moisture, further reducing the risk of dew forming.





▶ Paired with a William Optics GT81 to photograph the North America Nebula, NGC 7000, 146x 30" exposures

**KIT TO ADD**

**1.** Optolong L-Pro 2-inch filter

**2.** Canon or Nikon DSLR lens for widefield imaging

**3.** Canon EF or Nikon lens adaptor

▶ glow and noise. We were pleased to see that even when pushing the exposure time to five minutes there was no detectable amp glow in the images, even after an aggressive stretch. Beyond five minutes a very small amount of amp glow could be seen in the bottom corner, which was easily removed with calibration frames. Noise within the image was also minimal, and no hot pixels were found.

## Cool performance

With a clear night ahead, we proceeded to connect the QHY533C to our 3-inch refractor. The camera has 17mm of back focus, so even with our filter holder attached we still needed to add a short extension tube to achieve focus. Slewing over to the Triangulum Galaxy, M33, we were able to locate it easily with exposures of one second, which made alignment incredibly simple. Increasing the exposure time, we were impressed with the sensitivity of the camera and level of detail coming through in the individual frames. Happy that everything was set up and working, we programmed in our imaging run and set the camera firing.

Monitoring the QHY533C during the capture run, we were pleased to see that the temperature held steady at –20°C throughout, despite it being a very mild evening. The fans on the camera were very quiet and could barely be heard over background noise.

The QHY533C may be pitched as an entry-level camera, but with its features, sensitivity and image quality, this is a camera that even the most experienced astrophotographer would be happy to have in their collection.

▲ The Triangulum Galaxy, M33, with the same setup, 199x 30" exposures

# VERDICT

| | |
|---|---|
| **Build & design** | ★★★★☆ |
| **Connectivity** | ★★★★☆ |
| **Ease of use** | ★★★★☆ |
| **Features** | ★★★★☆ |
| **Imaging quality** | ★★★★☆ |
| **OVERALL** | ★★★★☆ |

# Sky-Watcher AZ-GTiX dual-saddle mount and tripod

An app-controlled, lightweight setup that offers double the mounting capacity

WORDS: PAUL MONEY

### VITAL STATS

- **Price** £399 mount head; £479 with tripod
- **Payload capacity** 6kg; 10kg using both saddles
- **Tracking mode** Dual-axis tracking
- **Tracking rates** No tracking, sidereal, lunar, solar, Point and Track
- **Slew speeds** 0.5x, 1.0x, 8.0x, 16x, 32x, 64x, 128x, 400x, 800x
- **Power:** 8x AA batteries or 7.5V–14V DC external power
- **Extras** L bracket, additional telescope saddle, extension pier
- **Weight** Mount head 2kg; with tripod 5.2kg
- **Supplier** Optical Vision Ltd
- **Email** info@opticalvision.co.uk
- **www.**opticalvision.co.uk

We're used to seeing equatorial mounts of varying sizes and capacities, along with equatorial tracking mounts for lightweight setups and ease of transport. Here we explore the latest offering from Sky-Watcher that does away with the need to polar align and instead provides a lightweight portable altaz mount, the AZ-GTiX.

Our review package included the AZ-GTiX mount and tripod with extension pier, plus an L bracket for attaching either a camera or another telescope. This mount is a dual-saddle mount, one where you can have two telescopes or a combination of equipment on just one mount. Its load capacity enables one lightweight telescope up to 6kg on one saddle or up to 10kg total weight if using both saddles.

The mount has an integrated Wi-Fi adaptor to provide its own network so that you can control the mount via the downloadable SynScan app or, if you prefer, you can attach an optional SynScan hand controller. For our tests we operated it as intended via the app, which is suitable for iOS or Android operating systems.


Paul's nighttime setup: Canon R6 and 400mm lens on one saddle and 80mm refractor on the other

## It takes two, baby

Power is provided either by eight AA-type batteries nicely hidden away in the body of the mount or via an external power supply, such as the typical power tanks provided for astronomical mounts. For our tests we used batteries and despite extensive testing during a particularly cold spell, the mount was still operational at the end of the review period. That's really good news for anyone wishing to use this in the field at a remote dark-sky site.

The versatility of the AZ-GTiX mount with its dual saddles meant we could set it up either with a single telescope, single camera setup, camera and telescope, camera and camera with different lenses, or two telescopes. With the telescopes, we could use one for viewing and one for astrophotography. We also set it up during daytime for solar viewing with a hydrogen-alpha telescope on one saddle and a white-light telescope on the primary saddle – useful, for example, for public events around a solar eclipse.

Attachment of the mount to the tripod is via a 3/8-inch thread, so photo tripods can be used; you can buy the mount without a tripod if you already own something suitable. We found the tripod supplied for our review perfect for the mount and ▶


## Mount head

The AZ-GTiX mount head is the business end of the system. It houses the electronics, Wi-Fi network adaptor, battery compartment housing eight AA batteries (not supplied), dual-axis Vixen-style adaptors, altitude clamp and azimuth knob. Compact and lightweight, it also features a bubble level to aid in setting up.

## L bracket and additional mounting bracket

An L bracket with tripod knob for attaching a camera or a second telescope is supplied. For the latter, a Vixen-style adaptor is also provided. Both the main Vixen attachment on the mount and the extra adaptor can be adjusted to ensure alignment of the optics in use.

## Ports

The AZ-GTiX mount head features a camera snap port for controlling a camera via the app, a port for an optional SynScan hand controller, an external power connector (7.5V–14V DC, 750mA) for an optional power tank, on/off switch and an integrated Wi-Fi adaptor for control via the SynScan app.

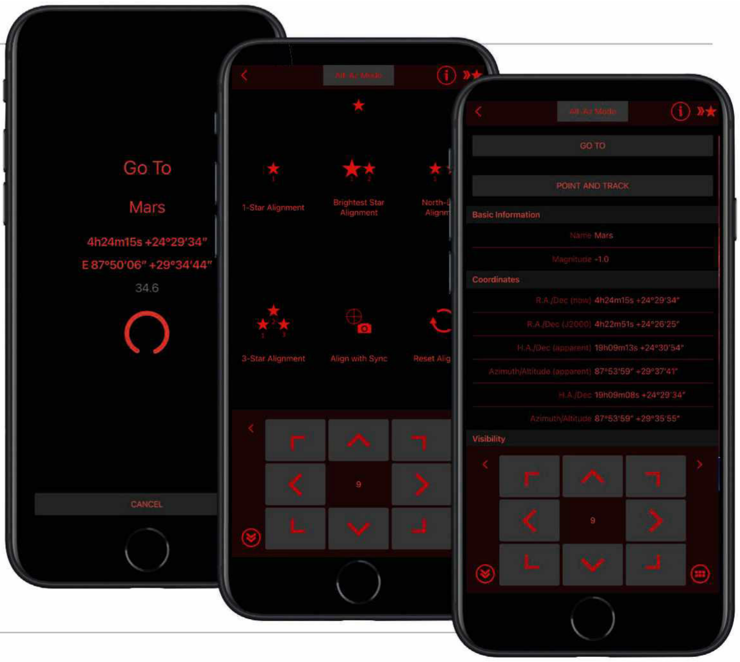

## Tripod

Our package included a sturdy adjustable tripod with legs extendable to a maximum height of 139cm. The accessories tray easily slots into place and also adds stability to the tripod, while an extension pier gives added height to allow long-focal-length telescopes to steer clear of the tripod legs.

## Built-in Wi-Fi and app

The heart of the system is the intuitive and easy-to-use Wi-Fi adaptor and the SynScan Pro app that controls the mount. In your smartphone settings, choose the SynScan network and connect to it, then open the SynScan Pro app. Tap 'Connect' and you're given a multitude of options to play with. Ideally use the star alignment facility to ensure good pointing accuracy and tracking. For best results, we used the three-star alignment and made a point of always choosing Polaris as the first. This helps in reaffirming that the setup is indeed pointing north.

Once aligned, you have multiple targets to choose from including Messier, NGC, IC, Caldwell and named deep-sky as well as Solar System objects, named stars, double stars and even comets. The Point and Track feature is interesting in that as long as 'location sensor' is turned on in the settings you can point the scope manually to a target to track it – useful if you don't have time to do an alignment.



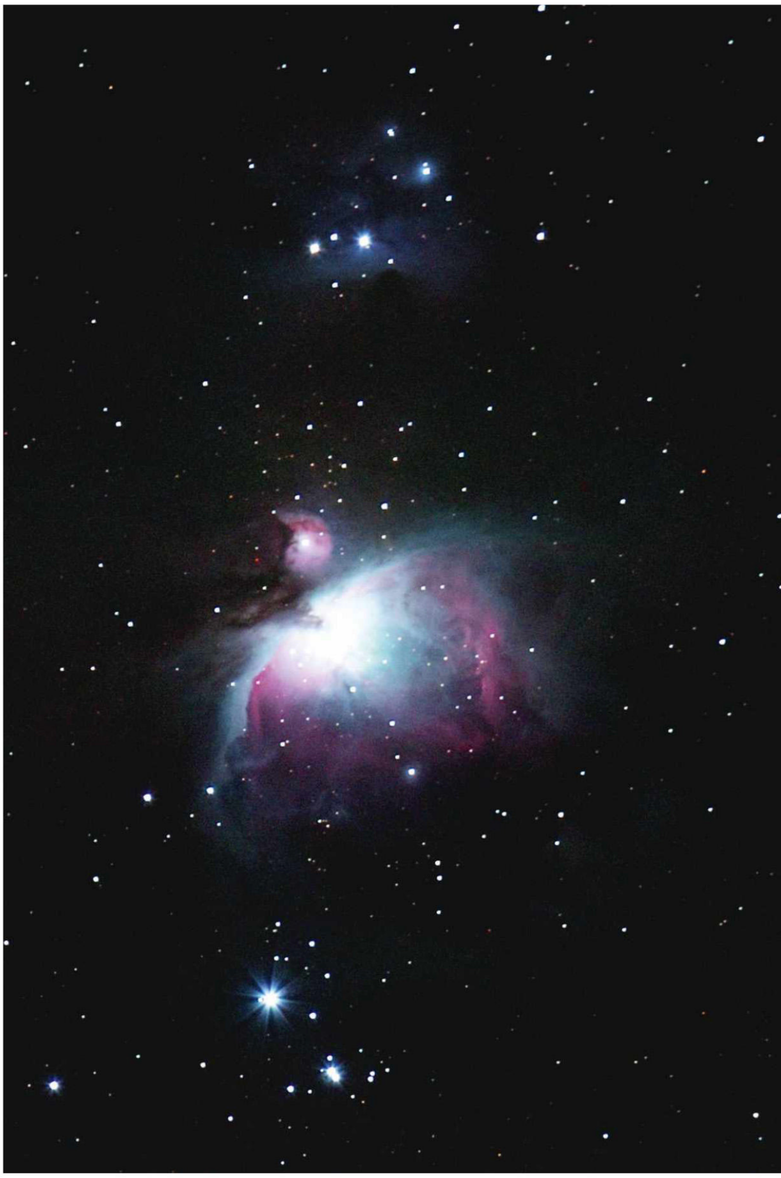

▲ Set up for daytime solar viewing, with a white-light telescope on the primary saddle and a hydrogen-alpha scope on the other


## Altitude and azimuth adjustment

The altitude clutch wheel allows free movement and rotation about the altitude axis or is clamped to allow the drive to engage. Similarly, the azimuth clutch knob does the same for the azimuth axis. With Sky-Watcher's patented Freedom-Find auxiliary encoders you don't lose alignment when manually moving the mount head.

@THESHED/PHOTOSTUDIO, PAUL MONEY X 6

▲ The AZ-GTiX proved a success for short exposures: M45, Canon R6 camera and 400mm lens, stack of 9x 30" exposures at ISO 3200



▲ Almost all the targets were kept nicely in the centre of the view over the test period. Sword of Orion, 22x 30" exposures at ISO 3200

▶ the supplied extension pier added a little extra clearance for longer-focal-length telescopes, so they don't catch on the tripod legs.

Initial setup involved aiming the mount with our telescope level and pointing north, then powering up and connecting the SynScan Pro app via the mount's Wi-Fi network. In the settings, we ensured the app had fixed upon our location and then all that was needed was to perform a star alignment. Using our Equinox 80ED refractor and 26mm eyepiece, we then proceeded on a tour of over 20 targets in the winter sky, with almost all centred close to the central 50 per cent of the view.

We placed a camera and large lens on one saddle and the telescope on the other and centred it on M45, the Pleiades star cluster, leaving it tracking while the camera took exposures and we periodically checked the view. The mount kept M45 at the centre of the view for 50 minutes, and the images we later processed showed that you can do astrophotography with this mount with short exposures. We also tested the AZ-GTiX's Point and Track feature, whereby without alignment you start up and aim the telescope at your target and leave it tracking. We did so on the Moon and, again, 20 minutes later it was still centred.

Overall, we were very impressed with this lightweight mount and found we quickly turned to it first for our observing and imaging sessions. We can highly recommend it.

## KIT TO ADD

**1.** Synscan handset and cable

**2.** 17Ah power tank

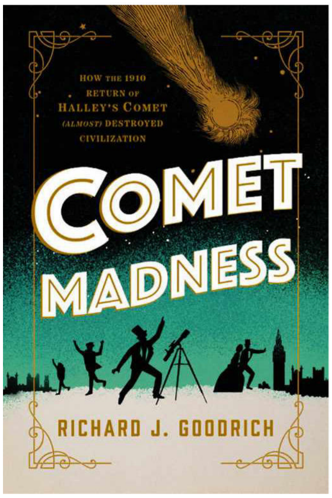
**3.** L bracket for second saddle

# VERDICT

| | |
|---|---|
| **Assembly** | ★★★★★ |
| **Build & design** | ★★★★★ |
| **Ease of use** | ★★★★☆ |
| **Features** | ★★★★☆ |
| **Tracking accuracy** | ★★★★★ |
| **OVERALL** | ★★★★★ |

New astronomy and space titles reviewed

# BOOKS




## Comet Madness

**Richard J Goodrich**
**Prometheus Books**
**£21.99 ● HB**

While the appearance of a bright comet in today's skies can invoke great excitement, history informs us that such a spectacle was more likely to provoke quite a different response – one of foreboding.

In a comprehensive overview of the literature that documented these apparitions at the time, *Comet Madness* offers a thorough sweep through the musings of those foretelling the reasons behind a comet's appearance and the consequences likely to befall the world from its fiery presence.

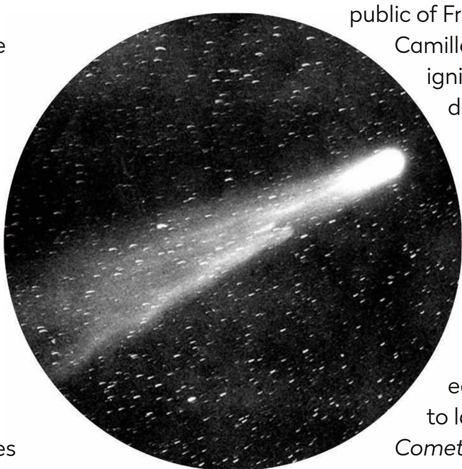
Author and historian Richard J Goodrich relates how civilisations reacted to the foretelling and subsequent sighting of a new arrival in the heavens. With the use of intriguing and often whimsical comet-based quotes to head up each chapter, he neatly catalogues in a flowing dialogue how centuries of archive material generally paint a desperate picture heralded by a comet's presence, of widespread fear among all walks of life.

Goodrich charts the achingly slow process humankind grappled with to understand comets, with huge swathes of the public for much of the time refusing to believe that they were anything but doom-laden toxic invaders that could only spell death and misery for the inhabitants of Earth. However, where there's a crowd there's business, and the author also details the unscrupulous characters out to make money off the back of such impending dread, with 'comet pills' and 'comet insurance' available for purchase.

In a solid and engaging read, Goodrich also captures the many-sided arguments presented as scholars wrestled to conclusively explain the arrival of 'hairy stars'. Notably, and because of the amount of archive material available from the period, the book focuses on the return of Halley's Comet in 1910, including the immense influence on both media and public of French astronomer Camille Flammarion, who ignited fears by declaring that the comet's tail would wipe humanity off the face of the Earth with its toxicity.

Featuring a wealth of historical information, from early Chinese archives to latter-day records, *Comet Madness* generates a collectively sound reflection of how such events impacted upon the human psyche, delivering an enjoyable amble through humankind's relationship with comets. ★★★★☆

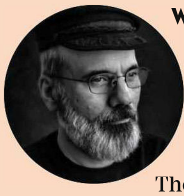
***Jonathan Powell** is an astronomy author and columnist*



**Harbinger of doom: Halley's Comet photographed not wiping out humanity in 1910**

HISTORIC COLLECTION/ALAMY STOCK PHOTO

## Interview with the author
### Richard J Goodrich



**Why do comets capture our imagination?**

Comets are unlike any other celestial object. They flicker into existence, grow until their silver tails stretch across the star field, and slowly fade. Following orbital paths that can take a thousand years to complete, they are silent voyagers in the interstellar darkness beyond the borders of our Solar System.

**How did ancient astronomers view comets?**

Before Edmond Halley, they were widely regarded as a message from the gods. For Chinese astronomers their disturbance of heavenly harmony symbolised divine displeasure, foreshadowing the fall of emperors. Political upheaval was a common interpretation in the West: Halley's Comet appeared before the Norman invasion and the fall of Constantinople. Reformation-era Christians believed they augured God's displeasure with their theological adversaries, and stood as indisputable signs that the apocalypse was at hand.

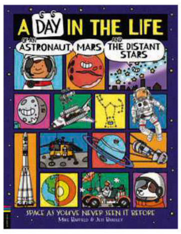
**What are the most ridiculous stories from the 1910 Halley's Comet hype?**

An *Arizona Daily Star* reporter allegedly interviewed a travelling Assyrian sage named Reetsmub. This descendant of Sennacherib said an ancient tapestry predicted the comet's appearance at the birth of Christ and the destruction of Earth in 1910. Amateur astronomer Edwin Naulty argued the comet's head was a lens that concentrated sunlight into a burning tail that would cause devastation on Earth.

***Richard J Goodrich** is an historian and author*

# A Day in the Life of an Astronaut, Mars and the Distant Stars

**Mike Barfield, Jess Bradley**
Michael O'Mara
£10.99 ● PB




Any book that introduces children to the night sky is to be encouraged. This book uses an engaging comic-book format while managing to pack in an incredible amount of information.

Its scope is comprehensive, covering our neighbours in the Solar System and the missions we have sent to visit them. It goes onward and outward to the stars, galaxies, nebulae and black holes. It tells the history of our exploration of the cosmos, including the Space Race, the Apollo missions, and past and future space stations. It also manages to explain complex concepts like gravity, dark matter and dark energy. All this is done in cartoon strips, packed with anthropomorphised stars, planets and asteroids, zooming about shouting 'Wheee!' a lot and bumping into things. The jokes don't get much more sophisticated than that, though I did like the solar wind explained as Sun farts.

The book may have benefitted from trying to cram less in, giving more space for more comic-book fun. Some missions and telescopes barely get mentioned, so there is lots of scope for further reading.

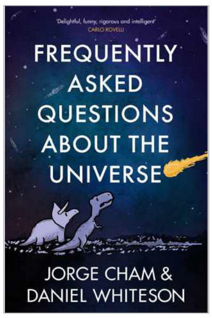
It may also have been good to have a library of high-quality space images to show alongside the book. Cartoon planets, moons, nebulae and galaxies, even with eyes and mouths, may be cute and friendly, but they miss the wow factor of the real thing.

Nevertheless, this is a fun and entertaining introduction to space for young children, and that is no bad thing. ★★★★★

***Jenny Winder** is a space writer and broadcaster*

# Frequently Asked Questions About the Universe

**Jorge Cham, Daniel Whiteson**
John Murray
£10.99 ● PB




Out of the 20 questions in this book, I've wondered about nearly all of them, usually after watching a sci-fi film. Why can't we teleport? Will an asteroid hit Earth? Why can't we travel back in time? And why was Biff such a bully?

Okay, that last one isn't in the book, but I bet that physicist Daniel Whiteson and researcher-turned-cartoonist Jorge Cham would have a funny, intelligent answer for us if it was. Each chapter tackles a different question, though a single answer isn't guaranteed. Some require a little lenience in the definitions of possible and impossible – travelling through time *might* not be impossible, albeit with very strict parameters; if general relativity isn't right about black holes, then it *could* be possible to survive one.

Cham and Whiteson's clever analogies help explain some of the concepts, but I did have to Google a phrase every now and then. Perhaps the target reader has a little more knowledge, but I would have appreciated a description of things like quantum states, or a refresher on the laws of physics.

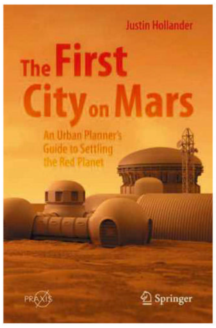
Still, this book is full of fun snippets of information that you'll want to share with others. It also has moments of awe and of sensitivity. "Is there another you?" may seem more like a question for philosophers than physicists, but it's incredible to think a quadrillion decisions had to occur since the Big Bang for you to exist right now. That's a quadrillion and one, I suppose, if you count your decision to read this review. ★★★★★

***Amy Arthur** is a science writer and speaker*

# The First City on Mars

OFF-WORLD IDEAS

**Justin B Hollander**
Springer
£24.99 ● PB




"There will be towns and then cities on Earth's Moon and on Mars sooner than you think," predicts Hollander in this fantastic book on engineering a future for humans on Mars. And if that's true, he argues, there is much to consider to ensure the survival of our future interplanetary citizens.

*The First City on Mars* is a book about space architecture in the context of planning cities on a planet with 38 per cent of Earth's gravity and a thin atmosphere of carbon dioxide. Such environments require new perspectives in urban planning, theorises Hollander, to ensure the survival of thriving communities living in such inhospitable environments. Drawing on lessons learned from older civilisations and their urban planning methods, the author lays out past and present habitat designs for off-Earth living.

He draws on the experiences of extreme environment communities on Earth, such as the Antarctic. There's an interesting summary of Moon exploration ,and recent lunar habitat and building design proposals; his review of the imaginative and futuristic designs of off-world city layouts as detailed by the O'Neill cylinder and Bernal sphere space settlements is particularly appealing. The final chapters summarise key findings from the extensive research previously presented, and Hollander proposes a compelling and enticing city design for Mars.

The book is well-written, clear and concise, supported with impactful visual content and imagery. Perhaps most importantly, it has universal appeal beyond that of engineering or architecture specialisms. Hollander makes a strong argument to dream big and plan now for a future in the first Mars city. ★★★★★

***Niamh Shaw** is an engineer and science communicator*

Ezzy Pearson rounds up the latest astronomical accessories

# GEAR


## 1 Pegasus Astro Indigo OAG

**Price** £179 • **Supplier** The Widescreen Centre • **www.widescreen-centre.co.uk**

**ADVANCED** Off-axis guiders allow your camera and guider to use the same view. This one is just 10mm deep, with 4mm for the telescope adaptor, but is solid enough to support heavy kit. An adjustable prism and large mirror help ensure excellent views.

## 2 Constellation washi tape

**Price** £2.50 • **Supplier** Cult Pens • **www.cultpens.com**

Washi tape is a paper-based, low-tack decorative tape that's easy to cut, tear and remove without causing damage. This design features dozens of constellations alongside fascinating astro facts.

## 3 CCD Guide 2023

**Price** €29 • **Supplier** CCD Guide • **www.ccdguide.com**

Locate the best astrophotography targets at any time with this downloadable guide. Along with software to plan your sessions, there's a database of 5,000 images and an updated planetarium.

## 4 ZWO 2-inch filter drawer system

**Price** £87.50 • **Supplier** 365 Astronomy • **www.365astronomy.com**

Quickly change filters using this magnetic drawer system that easily slides them in and out. This model has a new anti-light-leaking design for long exposures and comes with M54 or M48 threads.

## 5 W&W Astro digital four-channel controller

**Price** £60 • **Supplier** W&W Astro • **www.dewheater.com**

This powers up to four dew heaters with an adjustable output level, so you can keep your optics at the optimum temperature. It delivers 12V via a cigarette plug and has a maximum output of 36W per channel.

## 6 Small Steps and Giant Leaps playing cards

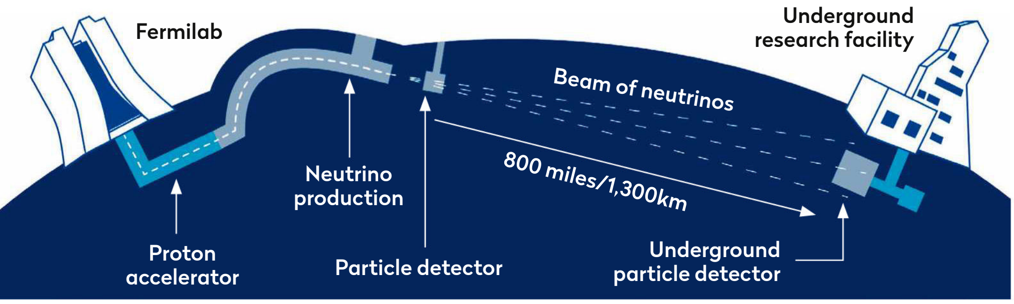
**Price** £20 • **Supplier** James Round Design • **www.jamesrounddesign.com**

Each playing card features a unique piece of artwork depicting a landmark in the history of spaceflight, from Sputnik through to the JWST, while the face cards feature different famous astronauts.

Melissa Brobby interviews Elena Gramellini

# Q&A WITH A PARTICLE PHYSICIST

Neutrinos – almost massless, neutral particles – could help explain why the Universe didn't just disappear in a flash of light after the Big Bang




▲ DUNE, the Deep Underground Neutrino Experiment currently under construction in the USA, will produce the most intense beam of neutrinos ever constructed

**Why is the study of neutrinos important?**
Neutrinos are truly fundamental particles. They are some of the elementary building blocks of our Universe. They come in three different types: tau, muon and electron neutrinos. In the 1960s, theoretical physicists wrote the rule book on particle interactions – known as the 'standard model' – which has been very solid for more than 50 years now. Yet, neutrinos break the rules.

**How does neutrino behaviour break the rules?**
They were assumed to be massless, and yet we have experimental proof that they do carry a tiny mass, thanks to the observation of 'neutrino oscillations', a phenomenon that makes neutrinos change flavour, so to speak, during their propagation. For example, most neutrinos from the Sun are electron neutrinos, but about two-thirds turn into one of the other two types by the time they get to Earth. Their behaviour could help explain why the Universe did not simply disappear in a flash of light just after the Big Bang.

**What is it about neutrino behaviour that could tell us about the early Universe?**
Neutrinos could help answer the matter–antimatter asymmetry problem. We know that antimatter exists, but we live in a Universe that's overwhelmingly made of matter. This is strange because there's nothing that makes matter special compared to antimatter, in terms of fundamental interactions. They should have been created in equal parts in the early Universe. It must be that there's a mechanism where for every billion particles of antimatter, a billion plus one particles of matter were created – a violation of the symmetry between matter and antimatter.

We know the fundamental components of protons, quarks, are partly responsible, but not enough to explain the overwhelming difference between matter and antimatter we see. By studying the oscillation patterns of neutrinos, we can understand how neutrinos contribute to this violation.

**How can studying neutrino oscillation patterns unlock this secret?**
Experiments such as the Short Baseline Neutrino programme will tell us if a fourth kind of 'hidden' neutrino exists. Future experiments – such as the next international flagship experiment, Fermilab's DUNE (Deep Underground Neutrino Experiment) that I'm working on – will be able to shed light on the matter–antimatter asymmetry in the Universe. These experiments are based on accelerator neutrinos. At Fermilab, we produce beams of neutrinos and build detectors along their path to record interactions at different distances from the origin point. By counting the number of interactions at different distances, we measure the oscillation pattern.

**That sounds challenging.**
Yes, counting neutrino interactions is quite tricky! Neutrinos are neutral, which means we can study them only if they interact. While they are the most abundant massive particle in the Universe, their probability of interaction is extremely small. So we need to build huge detectors to record a meaningful number of interactions.

**You're developing new technology for DUNE. What will it do and what new findings could it unlock?**
I'm developing a Liquid Argon Time Projection Chamber (LArTPC) with a powerful light-collection system. If selected, this technology will help us reach DUNE's goals faster, but mostly we expect it to enhance our understanding at low energies. This will unlock DUNE's potential in seeing neutrinos from the Sun and supernovae, as well as efficiently recognising proton decay events – an observation long coveted but never observed.

**Dr Elena Gramellini** is a Lederman Fellow at Fermilab whose field of research is experimental particle physics and neutrino detectors

**How is that process going?**
It's a collaborative effort. We're now working on proof-of-principle designs to ensure the viability of LArTPC's new sensors and characterise their performance. We'll then move to medium-scale prototypes where we'll record real neutrino interactions. This will allow us to put our technology to the test in a real physics environment.

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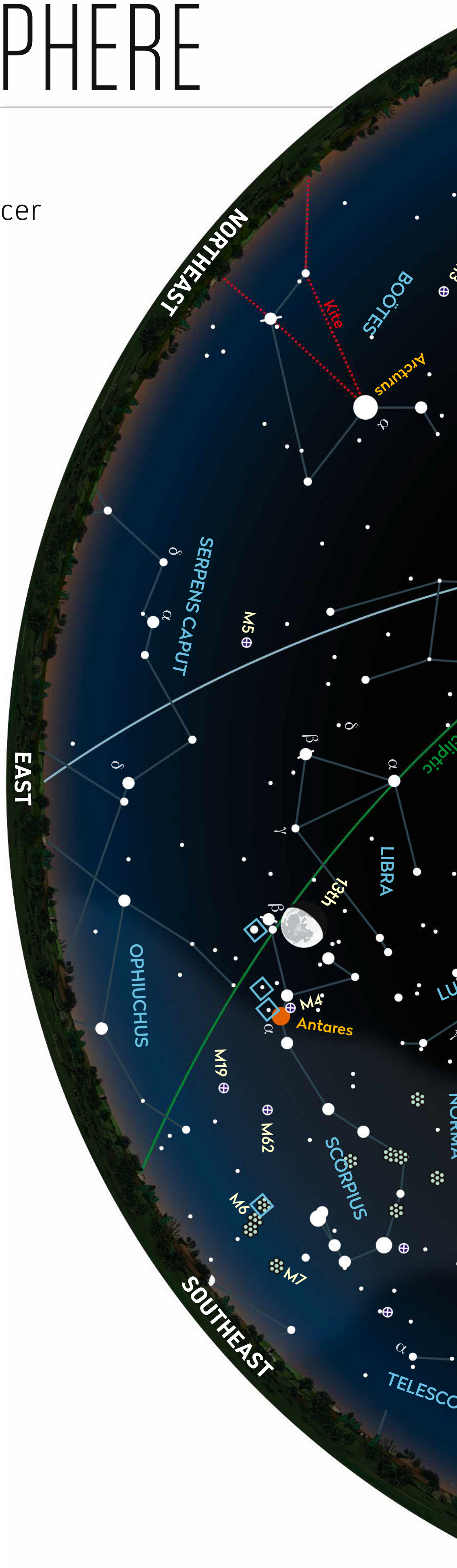
# THE SOUTHERN HEMISPHERE

**With Glenn Dawes**

Eyes peeled for the colourful, elusive Gamma Normids, and discover stunning targets in Cancer




## When to use this chart

**1 March at 00:00 AEDT (13:00 UT)**
**15 March at 23:00 AEDT (12:00 UT)**
**31 March at 22:00 AEDT (11:00 UT)**

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

### MARCH HIGHLIGHTS

There are only a few known meteor showers exclusive to the Southern Hemisphere. One is the Gamma Normids, active between 25 February and 28 March, and peaking around 15 March. Even at maximum only a few meteors are seen per hour, but their colour – white, yellow, and orange with some leaving trains – make the wait worthwhile, and their brightness helps overcome the unfortunate presence of the third quarter Moon in the morning sky during this year's peak.

### STARS AND CONSTELLATIONS

High in the southern evening sky is the ship Argo, of Jason and the Argonauts fame. Today, it has been broken up into the constellations Puppis (deck), Vela (sails) and Carina (keel), linked by the False Cross asterism. From northern latitudes all that is visible are the sails, even at maximum altitude; the rest of the ship is below the horizon. Earth's precession caused this 'sinking' – around 3,500 years ago the entire ship clearly sailed the Middle Eastern horizon.

### THE PLANETS

The first week of March sees brilliant Jupiter and Venus together low in the early twilight western sky. They soon separate, with Jupiter dropping towards the Sun as much brighter Venus slowly rises. Uranus spends the month dropping towards Venus, coming within 1.4° on 31 March before leaving the evening sky. Mars spends March in the northwest, departing around 23:00. Saturn appears out of the Sun's glow, rising about two hours before dawn by month's end.

### DEEP-SKY OBJECTS

This month we take a trip to the constellation of Cancer. The bottom star of the Crab's main Y-shaped asterism of stars is 4th-magnitude Iota (ι) Cancri. Although an impressive double star itself, our target lies 4° to the west. Phi¹ ($\phi^1$) Cancri (RA 4h 20.0m, dec. -54° 56') is a nice yellow-coloured mag. +5.5 star which contrasts well with its white companion Phi² ($\phi^2$), located 1° above (south). Phi² is a truly magnificent double with matching mag. +6.2 white stars, separated by 5 arcseconds, looking like car headlights.

Next up, a jump to the southern end of Cancer, near the border with Hydra, to the impressive spiral NGC 2775 (RA 9h 10.3m, dec. +7° 02'). At mag. +10.2, this galaxy has an obvious, elongated core with a star-like nucleus. Its surrounding halo (3 x 2 arcminutes) is stunning, being bright with some minor mottling.

## Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
URSA MAJOR
M106
M63
M94
CANES VENATICI
Cor Caroli
LEO MINOR
LYNX
GEMINI
Castor
Pollux
NORTHWEST
COMA BERENICES
Sickle
LEO
4th
M44
30th
31st
Mars
M35
M64
M60
M87
M86
M49
M65/66
7th
Regulus
CANCER
NGC 2775
CANIS MINOR
Betelgeuse
Procyon
VIRGO
SEXTANS
Celestial Equator
Rosette Nebula
ORION
10th
Spica
CORVUS
CRATER
Alphard
M104
Ghost of Jupiter
M48
Winter Triangle
M50
MONOCEROS
M47
M78
ANTLIA
HYDRA
M68
PUPPIS
PYXIS
Sirius
M41
M42
Rigel
CANIS MAJOR
WEST
M83
VELA
Eta Carina Nebula
Omega Cen.
CENTAURUS
CRUX
Jewel Box
Acrux
False Cross
NGC 2516
CARINA
Canopus
COLUMBA
LEPUS
ERIDANUS
Rigel Kent
Hadar
MUSCA
CIRCINUS
Gamma Normids
Peak 15 March
VOLANS
PICTOR
LMC
CAELUM
CHAMAELEON
DORADO
TRIANGULUM AUSTRALE
APUS
ARA
OCTANS
South Celestial Pole
MENSA
Tarantula Nebula
RETICULUM
HOROLOGIUM
Fornax A
SOUTHWEST
HYDRUS
SMC
47 Tuc
PAVO
Achernar
Peacock Star
TUCANA
PHEONIX
SOUTH